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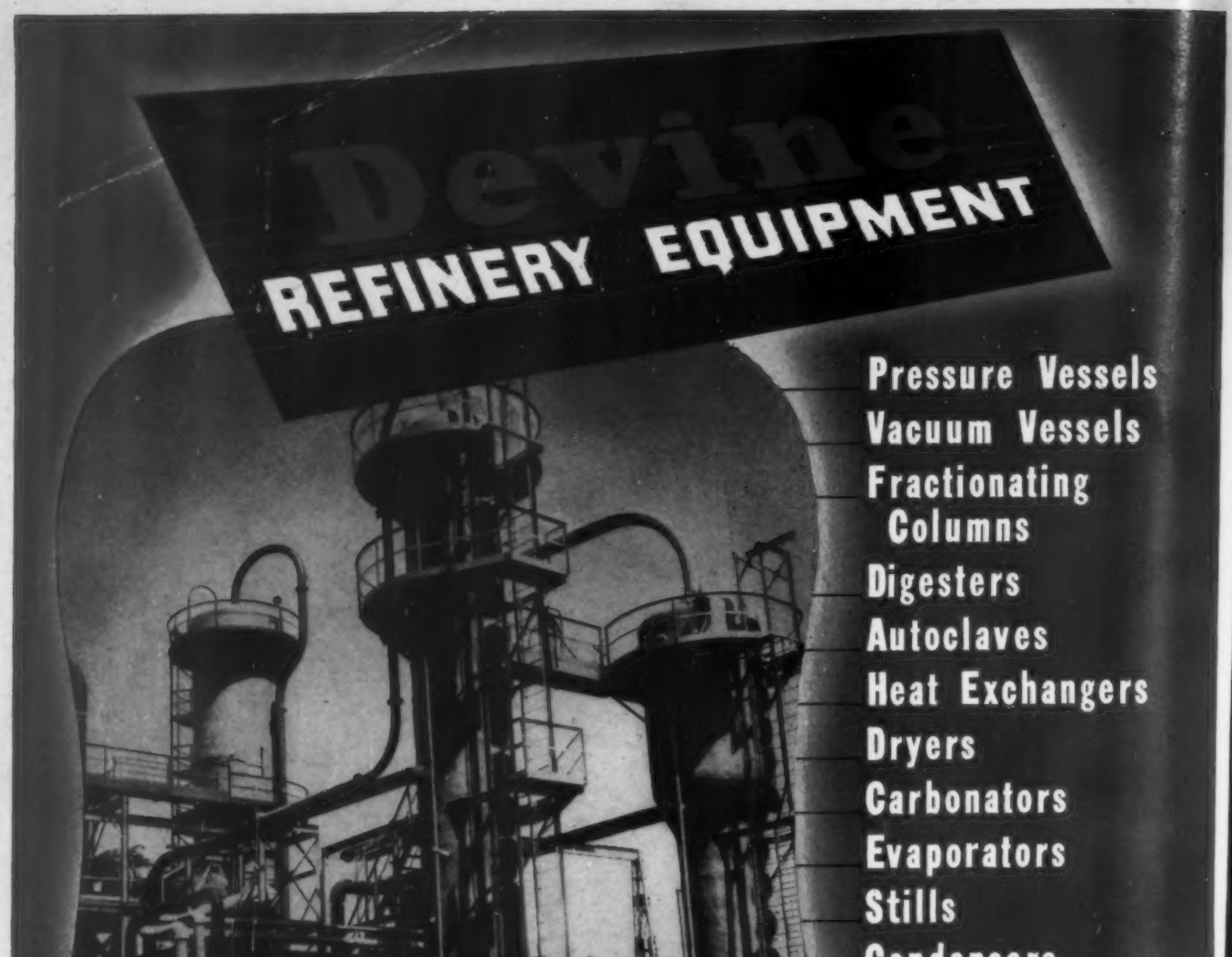

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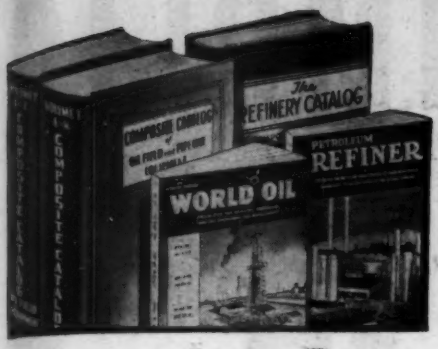

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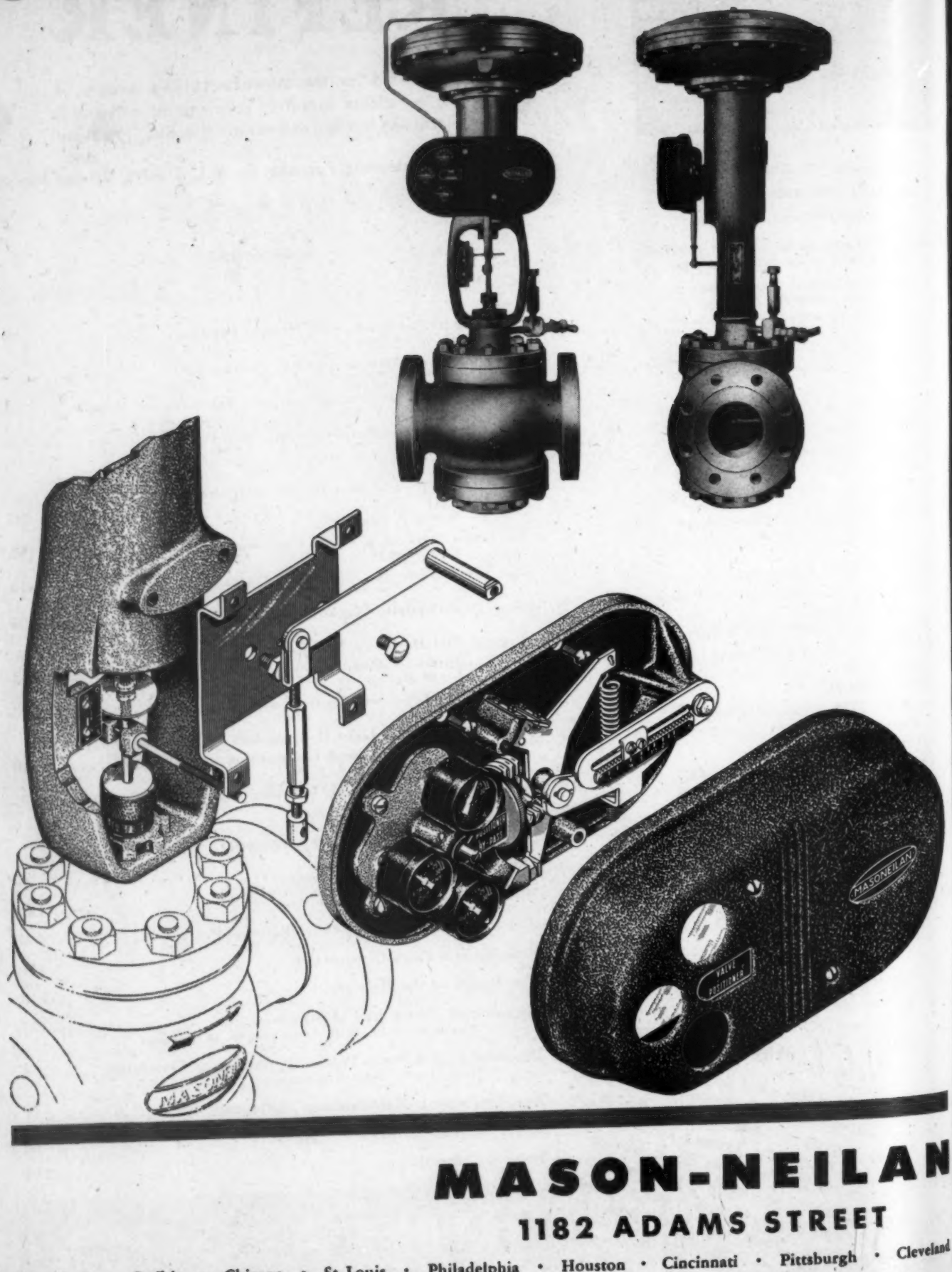

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VOLUME 26, NO. 9 SEPTEMBER, 1947

PETROLEUM
REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

TWENTY-FIVE years ago this month the first issue of PETROLEUM REFINER was delivered to its subscribers, under the name *"The Refiner and Natural Gasoline Manufacturer."*

Silver Anniversary

A lot of oil has gone through the stills during those 25 years.

The first issue, on its front cover, published an artist's conception of a white and pink stork, carrying a basket, and under it the wording "The Gulf Publishing Company, publishers of specialized oil journals, and the operating branch of The Refining and Natural Gasoline business announce the birth of a son!"

The publication was founded to give men engaged in the refining and natural gasoline industry a publication devoted to the particular problems and practices of that branch of the oil business. Its publishers had the theory that men so engaged had only an academic interest in the special problems of the oil producer or transporter, or the man engaged in marketing the product to the retail trade.

On the editorial page of the first issue appeared this statement: "For a long time we have believed that the refining branch of the oil industry deserved a publication devoted to its particular problems. For a long time we have believed that the natural gasoline business had grown to a point where a publication dedicated to its interests was needed . . ."

And then— "It is our hope that *The Refiner and Natural Gasoline Manufacturer* will become a publication for which the refinery engineer will be willing to write, knowing that the men who read it are his fellows in every respect . . ."

The past 25 years have been, with few exceptions, good years for the publication. The hope expressed in the paragraph above has been more than fulfilled. During the past 12 months more than 225 engineers, superintendents and executives have written articles of value which have appeared in the PETROLEUM REFINER. Its circulation has grown from a few hundred in 1922 to the point where its subscribers are numbered by the thousands.

Manufacturers of refining and natural gasoline plant equipment have used generously of its advertising space to the point where no two other oil publications can, combined, equal the amount of advertising carried in the PETROLEUM REFINER. That is important to the reader because the advertising pages carry information on products and services vital to the industry.

Over its lifetime, PETROLEUM REFINER has had four editors. Fred N. Williams, who had had practical experience in refining matters, and who is still employed as an executive in a refining company, was the first editor. Then followed Grady Triplett, a veteran in the Gulf Publishing Company. On his resigning to try his hand at personal writing, he was succeeded by George Reid, the lanky, lovable individual who left PETROLEUM REFINER to become executive secretary of the Gulf Coast Independent Refiners Association, and who is now employed on another oil publication. Triplett came back to the company to resume his editorship and continued until he retired as editor a short time ago. Triplett is still

How's this for GOOD DIGESTION?

TCC UNIT CHARGES 8 DIFFERENT STOCKS ON 8 SUCCESSIVE DAYS!

The remarkable flexibility of the TCC process is well illustrated by the following record from the daily log sheets of a TCC plant:

Date	CHARGE TO TCC PLANT CONTAINED:			
	Full Crude	Reduced Crude	Virgin Gas Oil	Kerosene
June 7	—	—	100%	—
8	—	—	75%	25%
9	—	—	—	100%
10	25%	50%	25%	—
11	70%	—	30%	—
12	50%	—	30%	20%
13	50%	30%	—	20%
14	50%	50%	—	—

Only a Houdry-licensed catalytic cracking unit could possibly accommodate such frequent changes of charge stock without shutdown and consequent considerable (and costly) loss of production. In the case of the TCC unit reported above, no major reduction in throughput, or in output of catalytic gasoline, resulted from the daily and drastic variations in feed charge.

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HOUDRY CATALYTIC PROCESSES

on the consulting staff. He was succeeded by Lud Daniels who came into the editorial department as plant visitation editor. Daniels came to the organization with adequate technical schooling, plus several years of actual experience in refinery design and operation.

The early editorial pages of PETROLEUM REFINER would be amusing if re-run today. There was one technical article in the first issue, and thereafter for a long time the editor had to write practically all the technical material. How different from today when the editor spends most of his time in studying trends and in personally visiting with the men in the industry who make it "tick" and who contribute to its pages such articles as were not available 25 years ago.

In 25 years there have been many changes, changes in processes, changes in economy, changes in attitude. If we are privileged to be living 25 years from now we imagine that PETROLEUM REFINER of September, 1972, will be as different from the issue of today as today's is different from September, 1922.

We are grateful to our readers, to the men who contribute to its editorial pages and to the manufacturers whose advertising makes possible the kind of publication we deliver at the low subscription price charged.—RAY L. DUDLEY, *Publisher.*

Basic Objectives

THE basic objectives of the petroleum industry's public relations program, now eight months old, should be kept uppermost in the minds of those of us in the petroleum industry who would see the industry gain its proper place in the public mind.

Main concern up until very recently has been the necessity for effective industry organization at grass roots, this in order to, 1) clarify facts, and 2) remove misunderstanding within the industry.

The prime objective, therefore, is efficient organization of the industry as a means of, 1) offsetting work of pressure groups within and without the industry, and 2) utilizing industry's facilities for producing public understanding.

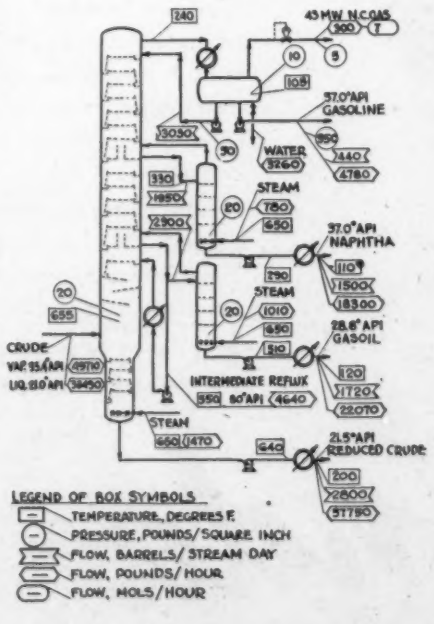
Chairman Franklyn Waltman notes in his latest report that all elements of the industry have been enthusiastic in their acceptance of the program which, he says, is ahead of the original schedule.

Hence, major emphasis up to this point has been on industry organization. The transition to public approaches is gradually being made. Whatever assistance the individual in the oil industry can give this tremendous effort should be volunteered because it's going to take pushing by all if the program is to succeed.

Standardized Symbols for Flow Sheets

Maximum utility for a process flow diagram is dependent primarily on choice of the information shown there, and secondarily on the readability of the drawing. Where complex process schemes exist, flow diagrams may become so involved that it is difficult to include all desired information and at the same time preserve a readable drawing. Operating departments, faced with this problem and with the necessity for keeping daily performance logs, have resorted to specially prepared "flag sheets" which possibly afford the maximum of ease and efficiency in the tabulation of temperature, pressure, and flow data.

These flag sheets are process flow diagrams with characteristic box symbols inserted at points where it is desired to record operating data. One box shape is used for temperature data, another for pressure data, and so on. The diagrams are usually prepared in pad form, and one sheet filled-in with current operating conditions constitutes each report.



Advantages realized in thus recording operating data also apply to a considerable degree with other flow diagrams, such as those giving process design figures. It seems desirable that our industry adopt a standardized set of these symbols. The ones shown here have been used by several companies, and are recommended for more widespread application.

They've got to be TEAMMATES

IF YOU WANT QUICK CLEANOUTS you've got to have a cleaner that's right. Both the cutter head and motor-hose combination have to work well together—as a team!

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TUBE CLEANERS

Cracking Sulfur Stocks With Natural Catalyst

R. C. DAVIDSON, Filtrol Corporation
Los Angeles, California

THE majority of catalytic cracking units installed during the war for the manufacture of aviation gasoline, operated on fairly high quality gas oil. In some cases, these gas oils came from special crude sources or from stocks stored in advance for initial operations; high yields of aviation gasoline were paramount and the economics were secondary. These units now are engaged primarily in the manufacture of motor gasoline, and economics are of considerably more significance. At the same time, there has been an unprecedented demand for furnace and fuel oils, which tends to reduce the available supply of high quality catalytic cracking feed stocks; there has also been a reduction in the amount of "sweet crude" received in many plants. As a consequence, it is expected that lower quality feed stocks will necessarily be used for future catalytic cracking and the effect of high sulfur-bearing gas oils on yields is of interest to many refiners.

Catalytic cracking has been carried out principally by means of two catalysts: a) the synthetic silica-alumina catalysts as typified by beads, pellets or powder, and b) the so-called "natural" or clay catalyst marketed as pellets for Houdry or TCC cracking plants or in powder form for "fluid" units. Several synthetic catalysts other than silica-alumina have been described, as for example, silica-magnesia[9] and alumina-boria,[10] but they have not been used for extended commercial cracking runs.

There have been additional improvements in both synthetic and natural catalyst manufacture. The production of synthetic in the form of microspheres is a recent development and, within a few months, a new natural catalyst with improved physical and catalytic properties, will be commercially available. However, only the catalyst types developed and used during the war are discussed here.

The effects on product distribution caused by cracking high sulfur stocks over natural and fresh synthetic catalyst have been compared by Evans.[4] The data given by Evans were obtained from laboratory bench scale units, but there was some evidence during 1944-45 of very rapid activity decline in several of the Thermofor catalytic cracking units to which high sulfur feed stocks were charged. Although these cases of deactivation may possibly have been due to heat or some contaminating agent other than sulfur, a repetition of the difficulty was avoided by either omitting the high sulfur gas oil from the feed or limiting the 90 percent point, usually to around 700° F. Steps were also taken to prevent deactivation by heat or contamination and fairly satisfactory catalyst life was subsequently observed. However, it is obvious that limitation of feed stock 90 percent point or actual elimination of certain types of charging stock is undesirable at a time when the demand for gasoline and high quality gas oil fractions are at a maximum. In addition to this problem there were a number of catalytic cracking unit operators who were changing from synthetic to natural catalyst at the same time that feed stock quality was deteriorating. Poisoning of the catalyst by high sulfur feed stock obscured or reduced the economic advantage which might have otherwise been obtained with the less expensive natural catalyst.

Consequently, it was of considerable importance to determine some method for overcoming the sulfur poisoning problem. Preferably, the method should be one that could be practiced immediately and not require the replacement of the entire catalyst inventory in the unit.

Considerable progress has been made toward fulfilling this objective. Feed stock restrictions previously thought to be necessary when cracking with natural catalyst can be largely eliminated, and more favorable product distribution may be obtained. This article presents the characteristics of catalyst which has been sulfur poisoned and the procedure for inhibiting the decline in activity caused by cracking gas oils containing relatively large amounts of sulfur compounds.

Clay Catalyst

Natural catalyst is prepared by the chemical processing of the naturally occurring material commonly known as bentonite or more accurately as sub-bentonite since it differs in some respects from the substance used as a drilling mud. The principal constituent of the sub-bentonite used for catalyst has been identified as montmorillonite. This clay mineral is one of the most important components of soil and, as such has received considerable study by soil scientists.

Some of the more significant physical properties of clay catalyst were recently reviewed by Webb and Ehrhardt,[10] and as they point out, montmorillonite possesses a crystal structure whereas the synthetic silica type catalysts are amorphous, i.e., have no regular arrangement of the silicon-oxygen tetrahedra. It can be shown that the crystalline portion of the treated montmorillonite is the active material with respect to catalytic cracking. Data given here show the relationship between the structure and successful catalytic cracking operation with high sulfur stocks; for this reason some understanding of the montmorillonite structure is of value.

The distribution of ions in the montmorillonite structure has been shown schematically in three dimensions in Figure 1, and the relationship of such a

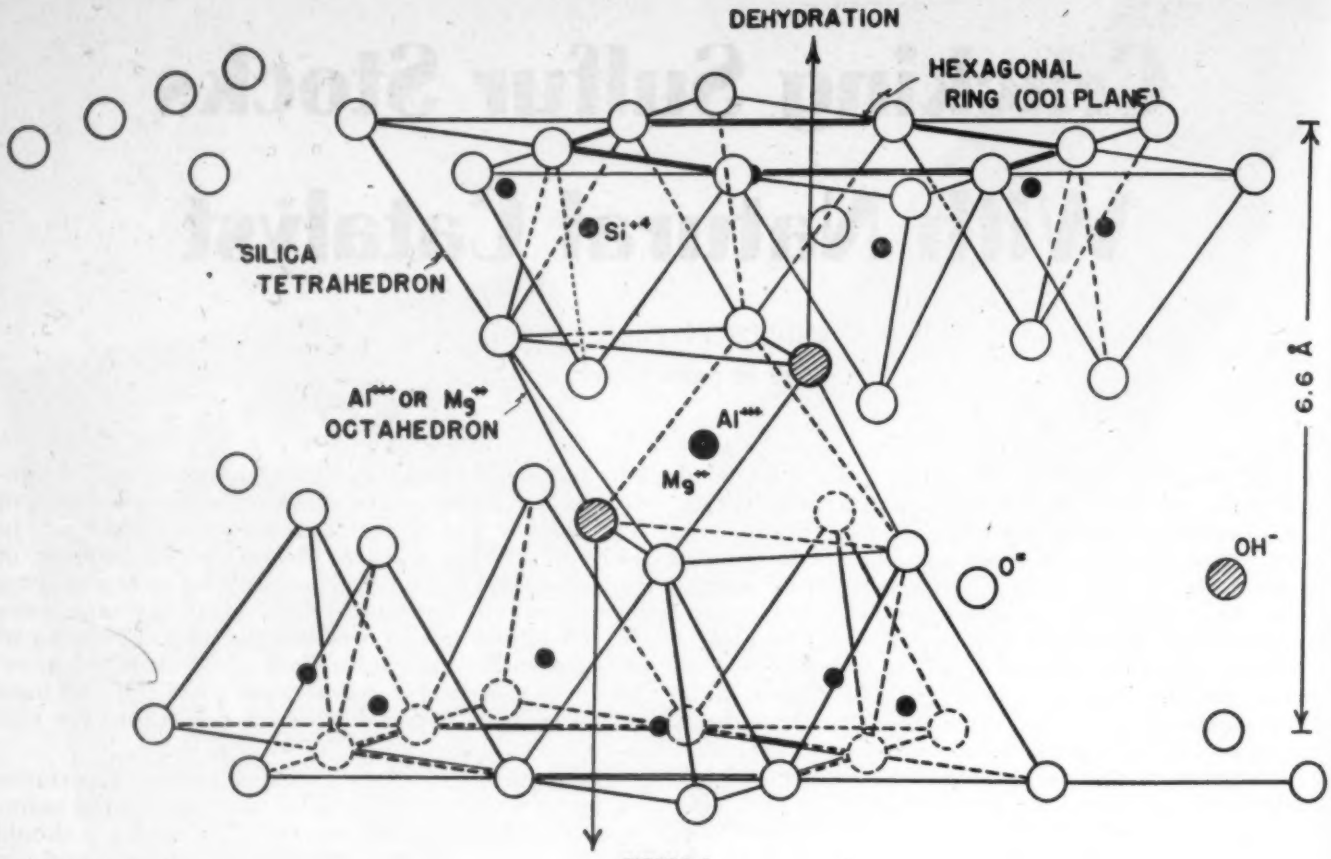

FIGURE 1

section to other plates has been represented in Figure 2. These drawings are based on the structure proposed by Hoffman, Endell & Wilm.[6] With respect to catalytic cracking, the significant item is the position of the OH, or hydroxyl ion, or the so-called water of constitution. It will be noted that the oxygen ions surrounding the silicon ions form tetrahedra which point inward and are linked to the alumina octahedra, or magnesia octahedra if magnesium ions have been substituted for aluminum ions. The hydroxyl ions, however, are not linked to the silica layers, and when the ions are drawn to scale, and the drawing expanded, the hydroxyl ions are beneath and above an opening in the top and bottom oxygen layers. This hexagonal ring or opening formed by the oxygen ions has been outlined by means of additional lines. The water of constitution begins, usually, to leave the catalyst at about 800° F., as suggested by the arrows passing through the hexagonal openings, and is essentially all removed by 1100° F. This temperature of removal is characteristic and is one means of identifying montmorillonite. For this purpose, the differential thermal analysis[5] is used.

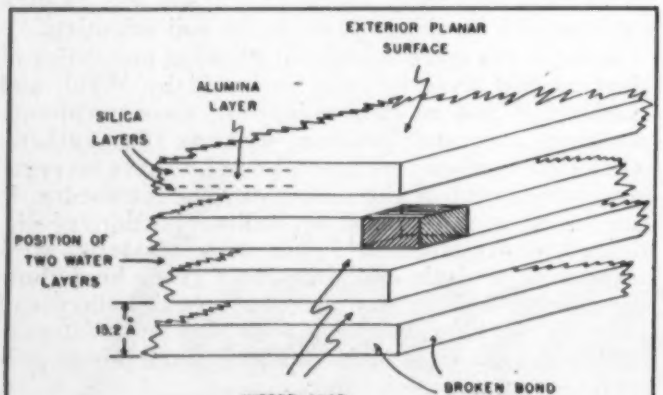

FIGURE 2

The equipment employed in the thermal analysis consists essentially of a furnace, sample receptacle, thermocouples, cold junction, galvanometers and heating rate controls. A motor driven autotransformer controls the heating rate at approximately 20° F. per minute.

The sample to be tested is placed in one well of the nickel block sample receptacle. One lead of the thermocouple in the sample makes another thermocouple junction with an inert material, generally calcined alumina, in another well of the nickel block. The other thermocouple leads from the sample and the alumina are connected to a mirror galvanometer through a cold junction. The temperature differentials between the alumina and the sample, which arise during heating, cause deflections of the galvanometer, and the deflections are recorded on photographic paper. Typical thermal curves for activated montmorillonite are shown in Figure 3.

A horizontal line represents no heat effect as compared to the inert sample when the temperature of the furnace is raised. A deflection downward represents an endothermic effect and a deflection upward represents an exothermic effect. Numbers along the bottom of the figure refer to the furnace temperature.

The thermal curves in Figure 3 are for samples of catalyst which have been calcined for five hours under one volume of bone dry air per minute per volume of catalyst at the temperatures shown on each curve. Since catalyst is rapidly heated during addition to a commercial cracking unit, used catalyst will generally give a curve similar to one of those shown in Figure 3. Some significant changes occur in the catalyst dur-

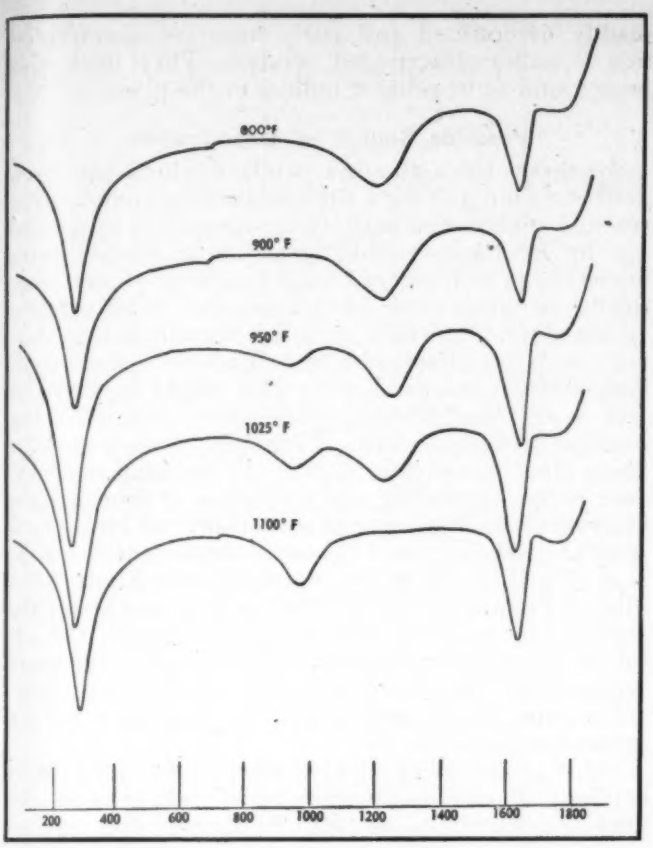

FIGURE 3

ing the heating period and these may be explained by reference to Figures 1, 2, 3 and 4. The top curve in Figure 4 is for fresh fluid catalyst which has a volatile content at 1700° F. of approximately 20 percent basis clay as charged. The majority of the water present occurs as two layers between the interplanar surfaces of the montmorillonite plates as represented in Figure 2. The identity distance of the (001) X-ray reflection plane decreases from 15.2 angstrom units to 9.8 when this water is driven out. If the catalyst is not heated above 600° F., it is possible for the montmorillonite to swell again to 15.2 angstrom units when exposed to high humidity air or when placed in water. It is this swelling property which caused the early production of TCC pellets to break down when exposed to steam condensate in certain portions of the unit, or to plug precipitator hopper standpipes in startup of fluid units. If heated above 600° F. the catalyst will no longer swell or pick up water between the interplanar surfaces. The physically absorbed water is then held in pores and the first thermal deflections of the curves in Figure 3 represent the endothermic effect from the loss of this type of water whereas the initial deflection for the first curve of figure 4 represents the loss of both pore and interplanar water. If duplicate samples, one calcined and the other uncalcined are analyzed in the same apparatus, the difference in the size of the first thermal deflection is even more pronounced than has been presented here.

Dehydration

If the catalyst is calcined at temperatures well above 600° F. such as has been shown in Figure 3, another change occurs. It has been established that the second thermal deflection arises from the loss of the hydroxyl water represented by the hatched circle in Figure 1. Presumably this water leaves the structure through the holes in the upper and lower silica sheets. The hydroxyl ions must undergo some distortion in leaving the structure and the position of these ions probably governs to some extent the relative ease with which they are removed. Whether or not this is the explanation, the size of the thermal depression decreases for samples which have been calcined for the same length of time but at various temperatures between 800° F. and 1100° F. prior to being analyzed. However, a new deflection appears, starting at about 800° F., which increases as the size of the deflection for the original hydroxyl water decreases.

TABLE 1

Santa Maria Coker Gas Oil

ASTM DISTILLATION:	
I.B.P.	466° F.
10 Percent	541
20 Percent	562
30 Percent	584
40 Percent	606
50 Percent	629
60 Percent	652
70 Percent	680
80 Percent	710
90 Percent	740
E. P.	760+
Gravity °API	23.2
Pour	20
Sulfur, Weight Percent	3.52
Nitrogen, Weight Percent	0.27

The amount of hydroxyl water initially present amounts to about 3 or 4 percent. It has been found that the new deflection occurring between 800° F. and 1000° F. represents between 1.5 and 2 percent water sorbed at some temperature above 350° F. and below 800° F. for relatively moderate partial pressures of water vapor. Catalyst which has been heated to 1100° F., but not above 1450° F., and has had an opportunity to sorb moisture, such as the last curve in Figure 3, is termed *rehydrated* catalyst. Catalyst which has been *dehydrated,* that is heated enough to drive out the hydroxyl water but not enough to destroy the structure, and has not had an opportunity to pick up moisture, would give a flat line in the thermal analysis, out to the point above 1450° F. when the destruction of the montmorillonite structure starts.

From the Pauling packing principles, which are used in assigning the sharing of bonds in silicate minerals, it is clear that the loss of hydroxyl water will require a redistribution of forces in dehydrated catalyst. Presumably, some of these bonds are unsatisfied in catalyst in the dehydrated state and the rehydration of the catalyst provides the necessary satisfaction. It is also obvious that the regenerator in the usual catalytic cracking operation will dehydrate the catalyst and that cracking usually takes place with an essentially dehydrated catalyst.

Catalyst Deactivation

The result of cracking high sulfur stock with dehydrated catalyst may be observed in Figure 5. This test was made with coker gasoil from Santa Maria crude. The gasoil had inspections as listed in Table 1.

Cracking temperature was 800° F. for 10 minutes; 50 cc of gasoil were passed over 200 cc of Filtrol TCC (natural) catalyst in the "Cat A" testing equipment.[1] East Texas gasoil, the standard "Cat A" test stock, was used to determine the initial activity of the catalyst and to obtain a "Cat A" activity after every eight cycles on Santa Maria gasoil. The activity decline is similar to that observed elsewhere on this same type of stock.[7] Recalcination under one V/V/min. of bone

dry air after 63 cycles operation produced an apparent rise in activity but it was not permanent. Of significance is the large increase in gas and carbon yield when cracking East Texas gasoil (ETGO) with catalyst deactivated by high sulfur stock. Such effects are characteristic of this type of poisoning in both small scale and commercial catalytic cracking units.

Definite changes in the physical properties may be observed in natural catalyst which has been deactivated by heat, or steam or some other agents. These changes easily account for the loss of activity but no such observations have so far been made in the case of sulfur poisoned catalyst.

Natural catalyst deactivated by Santa Maria gasoil in the 200 cc units was inspected for physical characteristics; the comparison between surface areas as determined by the BET[3] method (low temperature nitrogen adsorption), initially and after 60 cycles on Santa Maria gasoil and the "Cat A" activities are listed below:

	Surface m^2/gm	Percent 410° F. E.P. Gasoline*
Initial	270	38.4
Final	251	21.6

* 900° F. Reactor, other conditions "Cat. A.".

X-ray and thermal analyses were also made on this catalyst before and after cracking SMGO, and the results showed that no observable physical change had taken place. Consequently, it was apparent that the catalyst had been contaminated by a substance which did not affect its physical properties.

Normally catalyst activity and surface area are related to one another by a definite correlation so that the above tabulation indicates a useful method for determining the amount of poisoning which has taken place. If activity is quite a bit lower for a given surface area than it should be as determined from some type of correlation curve as is shown in Figure 6, then such a catalyst may very likely be contaminated by sulfur.

Deactivation with H_2S

It was found in the laboratory that exposure of natural catalyst to hydrogen sulfide at cracking conditions would cause as great an activity decline as approximately 30 cycles of Santa Maria coker gasoil. Typical data are shown in Table 2. In this test catalyst was dehydrated by calcination for five hours at 1050° F. under one volume of bone dry air per volume of catalyst per minute. After calcination the catalyst was exposed to hydrogen sulfide for one hour at 900° F. at a rate of 1 V/V/min.

TABLE 2

Deactivation with Hydrogen Sulfide

Pretreatment A	5 Hrs. at 1050° F. under 1 V/V/min. bone dry air	
Pretreatment B	None	H_2S 900° F.** 1 Hr. 1 V/V/min.
Percent 410° F., E.P. Gasoline	39.3	25.7
Weight Percent Gas	8.1	10.8
Gas Density	1.33	0.69
Gas CF/Barrel	236	608
Weight Percent Carbon	4.6	6.9
Weight Percent Conversion	49.2	40.4
Carbon Production Factor*	1.00	2.38

* Weight percent carbon produced divided by weight percent carbon produced by standard catalyst at the same conversion.
** H_2S measured at room temperature and pressure.

The large volume of gas having a low density indicates a relatively high production of hydrogen. This and the high carbon producing factor (CPF) are readily determined and fairly accurate characteristics of sulfur deactivated catalyst. They have also been found to be reliable indices in the plant.

Possible Source of Deactivation

Synthetic silica-alumina catalyst which has been used in a fluid unit for a sufficiently long time to have reached equilibrium activity is susceptible to poisoning by hydrogen sulfide at cracking temperatures whereas the well washed fresh synthetic shows practically no effect from such exposure. Bead catalyst (silica-alumina), which picks up very little iron during use, is not affected by H_2S. Therefore, the deactivation of natural catalyst by H_2S might logically be laid to the iron which is inherently present in the catalyst structure. Natural catalyst is very dark or black after exposure to H_2S in the cracking temperature range suggesting the formation of iron sulfide. However, the admixture of iron in several forms with natural catalyst caused the usual amount of deactivation characteristic of iron contaminated catalyst but after the exposure to H_2S, the activity was about the same as for catalyst which did not contain the admixed iron. Several other experiments were made without any data being obtained which clearly indicated that the deactivation was caused by the presence of iron.

On the other hand, natural catalyst which had been calcined at various temperatures, rather than the standard calcination at 1050° F., showed different degrees of deactivation when treated with H_2S. These catalysts would have had thermal curves corresponding roughly to those given in Figure 3. It was mentioned in the discussion covering the crystal structure that natural catalyst loses its water of constitution when heated at or above 1100° F. in a moving air stream such as occurs during regeneration in commercial operations. In order to compensate for this loss, fresh catalyst will rehydrate, or sorb water at the normal reactor temperatures and steam partial pressures, particularly in the stripping section. It appears logical from structural considerations, and it can be shown by other means, that the alumina in the catalyst structure is the source of the sorption tendency. As disclosed by Bayley,[2] alumina will irreversibly sorb hydrogen sulfide and this sorption reaches a maximum in the range of catalytic cracking reactor temperatures. Since H_2S and H_2O exhibit several analogous chemical reactions, it is possible that dehydrated catalyst would sorb H_2S. There is considerable evidence which indicates that the aluminum ion is the active center of cracking catalyst; hence, sorption of a poison on or near this ion should be especially detrimental to the distribution of cracked products.

Synthetic catalyst does not possess the same magnitude of rehydration as natural catalyst, either in quantity sorbed or heat effect. Presumably this is because the synthetic does not have a crystal structure and therefore it might be anticipated that it would not suffer severe deactivation from "sulfur poisoning" if such poisoning actually does arise from sorption of sulfur compounds on the alumina.

Consequently, there was some support for the theory that the crystal structure and dehydration phenomenom were connected with the observed deactivation caused by sulfur compounds. By maintaining the catalyst in a rehydrated condition whereby the sorption of sulfur compounds might be reduced t a minimum, the deactivation might be prevented.

In order to test this theory, tests were run in which

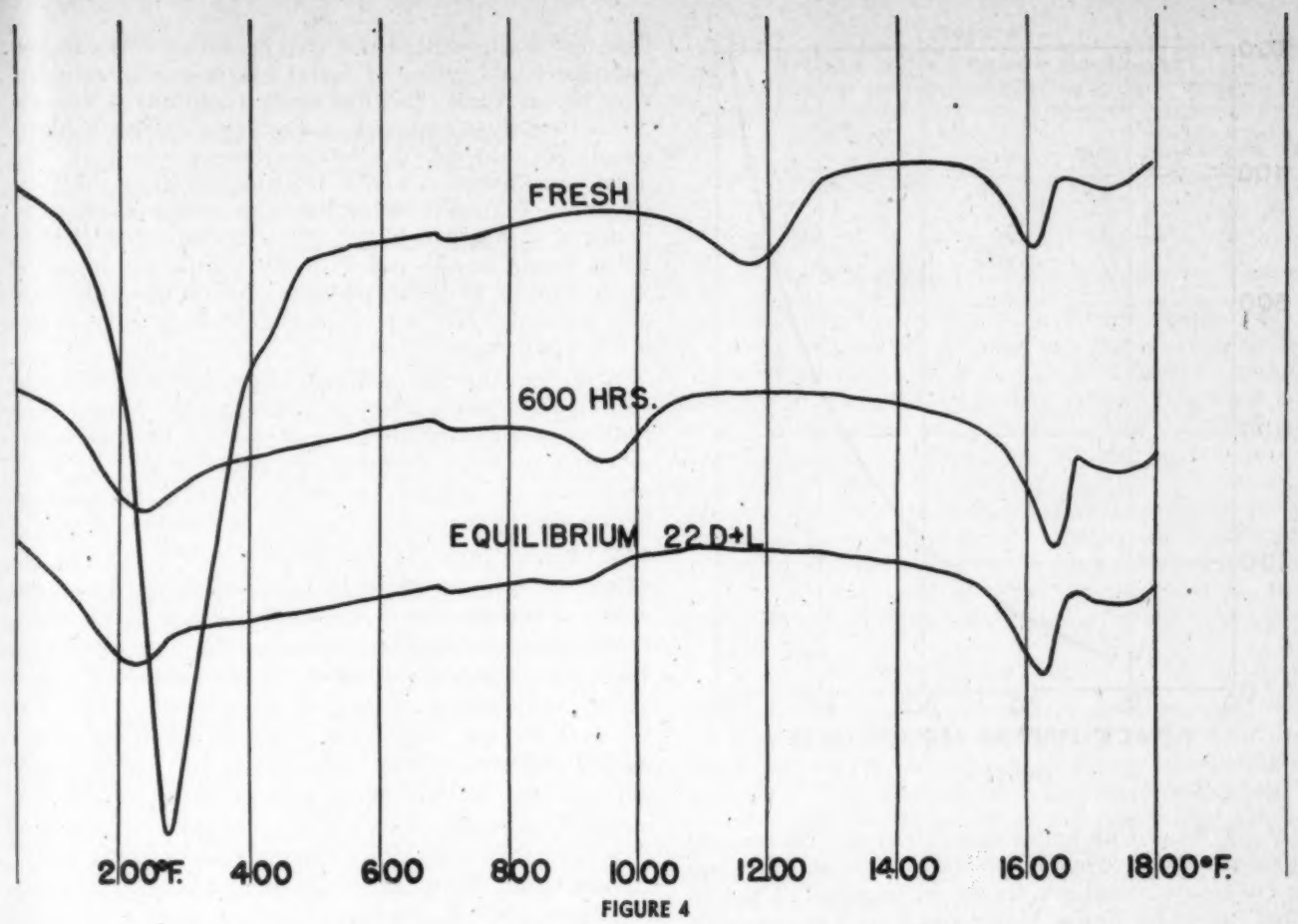

FIGURE 4

rehydrated catalyst was exposed to H_2S at the same temperature as on those experiments for which data are given in Table 2. Rehydration of catalyst prior to the exposure to dry H_2S was not a satisfactory means of protecting the catalyst because the conditions of exposure caused dehydration during the hour that one volume of H_2S per volume of cat per minute was passing over the catalyst. The catalyst was subsequently maintained in a hydrated state during exposure to H_2S by disbursing the gas through water held at a high enough temperature to maintain the outlet temperature of the H_2S-H_2O mixture at 200° F. As a blank for this test, H_2S was blended with nitrogen to give the same partial pressure as was obtained with the H_2S-H_2O mix. Data for these tests are shown in Table 3.

From the results, it will be observed that the catalyst which was not protected by rehydration exhibited a decline approximately equivalent to that given in Table 2. The catalyst which had been maintained in a relatively rehydrated condition suffered only a slight amount of deactivation.

The protection of catalyst by rehydration was verified by running Santa Maria coker gasoil in the 200 cc unit over catalyst which had been rehydrated after each regeneration period. For this series of tests the Santa Maria gasoil was emulsified with 5 percent

TABLE 3

Protection of Catalyst by Rehydration

Pretreatment A.....	5 Hrs. at 1050° F. under 1 V/V/min. bone dry air		
Pretreatment B.....	None	H_2S 1 V/V/min. 900° F. +Sat. H_2O 200° F.	H_2S 1 V/V/min.+ N_2 2 V/V/min. at 900° F.
"Cat A" Results:			
% 410° F. E.P. Gasoline..	38.9	36.8	25.2
Weight Percent Gas.....	8.3	7.7	10.4
Gas Density.....	1.41	1.27	0.76
Gas CF/Barrel.....	228	235	531
Weight Percent Carbon....	4.2	3.5	6.0
Weight Percent Conversion	46.7	42.0	37.8
Carbon Production Factor.	1.05	1.13	2.46

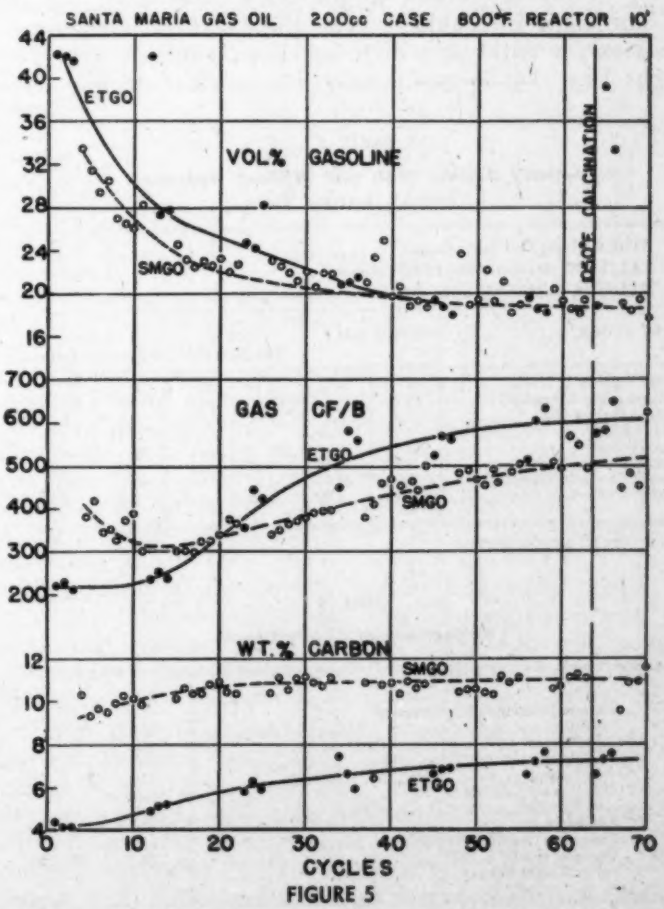

FIGURE 5

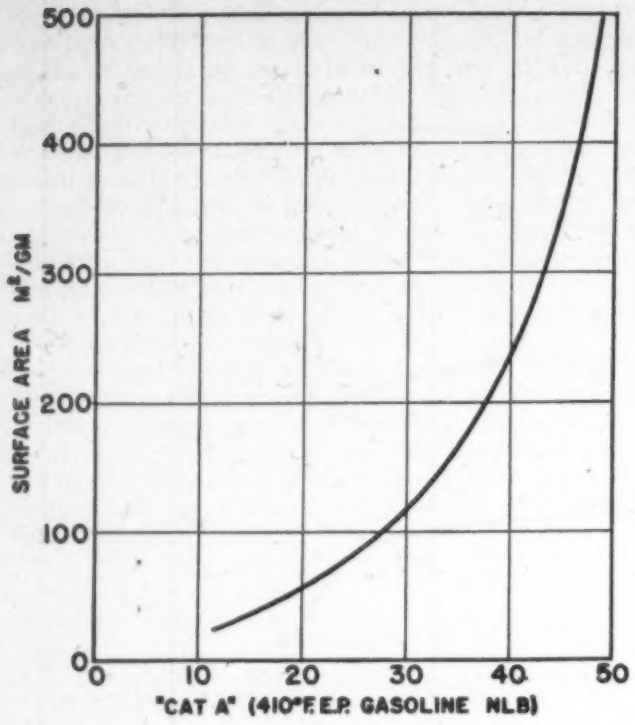

FIGURE 6

water by weight as being equivalent to the amount of process steam used in normal catalytic cracking. The curves obtained are shown in Figure 7. The reference curves for Santa Maria and East Texas gasoils without hydration were taken from Figure 5. Although there was some decline, the gasoline yield tended to reach a stable value, and the gas and carbon, instead of increasing, showed a decrease.

The data in Table 4 give the "Cat A" activity indices for catalyst which has been exposed to: a) light East Texas gasoil only, i.e., normal decline in this test equipment, (first two columns); b) catalyst exposed to 23 cycles of Santa Maria gasoil, rehydration before each cracking cycle (columns 3 and 4); and c) catalyst exposed to 24 cycles of Santa Maria gasoil without rehydration, (columns 5 and 6). The data for columns 5 and 6 were taken from the tests shown in Figure 5. Since East Texas gasoil partially restores catalyst activity, the alternate 3 cycles on East Texas gasoil and 8 cycles Santa Maria gasoil for a total of 24 cycles on Santa Maria gasoil is actually not as severe a test as the 23 successive cycles with rehydration.

Although the Santa Maria gasoil has a high sulfur content and low gravity it is not a particularly high boiling stock and there was some question as to whether or not a heavier feed stock might be more injurious to catalyst activity. Several samples of heavy gasoil were run through a number of cycles and no abnormal decline occurs in 200 cc unit because of high end point of the feed stock. As an example, a series of tests is shown in Figure 8 in which the catalyst activity was obtained by three cycles on East Texas gasoil followed by 23 cycles of heavy gasoil, rehydrating after each regeneration. The "Cat A" activity on East Texas gasoil was then determined and five cycles were made on heavy gasoil without rehydration before each cracking period. The inspections of this heavy gasoil are given in Table 5. It will be noted that this material has a lower sulfur content than Santa Maria gasoil but the 90 percent is almost 300° F. higher.

Complete "Cat A" data for the 3rd, 29th and 37th

TABLE 4

Activity Decline With and Without Hydration
"Cat A" Activity Tests

STOCK—Light East Texas Gasoil
CATALYST—Standard Filtrol TCC Catalyst
REACTOR TEMPERATURE—800° F. 200 cc Cases

TEST STOCK	ETGO ONLY		SMGO With Hydration		SMGO Without Hydration	
Cycle Number	3	29	3	29	3	36
Volume Percent Gasoline*	38.7	34.6	39.4	34.6	41.6	21.6
Weight Percent Gas	5.3	5.4	7.8	5.2	7.4	8.6
Gas Density	1.34	1.32	1.37	1.32	1.48	0.64
Gas CF/Barrel	183	156	221	154	209	558
Weight Percent Carbon	4.35	4.16	4.12	3.0	4.23	5.94
Weight Percent Conversion	45.2	42.9	45.7	38.4	48.9	34.0
Carbon Production Factor	1.18	1.30	1.08	1.18	0.96	2.96

* "Cat A" Activity Index.

TABLE 5

Inspections of Heavy Gasoil

Gravity	23.1
Vacuum Distillation °F., Corrected:	
I.B.P.	554
10 Percent	610
30 Percent	684
50 Percent	778
70 Percent	882
90 Percent	1020
Aniline Point	175
Conradson Carbon Weight Percent	0.74
Viscosity at 100° F. SSU	259
Sulfur Weight Percent	2.52

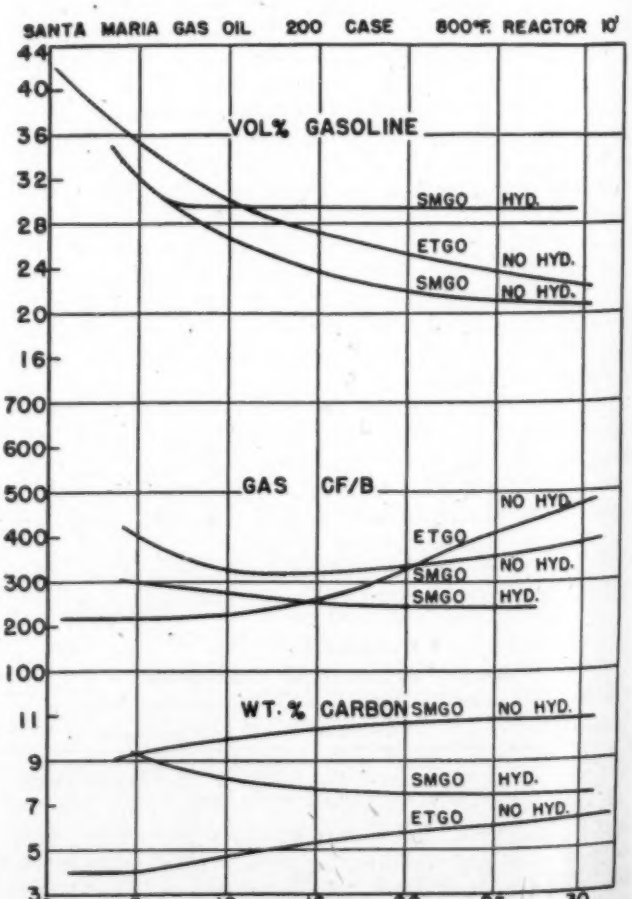

FIGURE 7

cycles after charging the heavy gasoil are given in Table 6.

TABLE 6

Effect of Heavy Gasoil Containing 2.3 Percent Sulfur

CATALYST:—Standard Filtrol TCC Catalyst
PRETREATMENT:—5 Hrs. at 1050° F. 1 V/V/min. bone dry air
STOCK:—Light East Texas Gasoil

TEST	Blank	After 23 Cycle HGO+Hydration*	After 5 Cycle HGO, no Hyd.
Cycle Number	3	29	37
Reactor Temperature, °F.	890° F.	890° F.	888° F.
Volume Percent Gasoline	39.1	39.1	24.3
Weight Percent Gas	16.92	11.36	11.70
Gas Density	1.22	1.18	0.548
Gas CF/Barrel	536	372	825
Weight Percent Carbon	4.99	3.54	8.20
Weight Percent Conversion	61.8	54.1	48.1
Carbon Production Factor	0.72	0.77	2.42

* No process steam used.

It will be noted that the deactivation caused by Santa Maria gasoil when cracking with rehydrated catalyst is approximately normal. The catalyst which was not hydrated before cracking shows the usual characteristics of sulfur poisoning-low gasoline yield, low gas density and high carbon producing factor.

Process Steam Protection

An alternate method for preventing the deactivation of natural catalyst by poisonous feed stocks is the use of high process steam rates. This procedure was observed by Houdry Process Corporation to stop the activity decline normally found with gasoil from Santa Maria Valley crude. In Table 7 are listed data obtained with the same heavy gasoil (HGO) that was used to make the test covered by Table 6, but with process steam added as an emulsion, 15 gms. of water per 100 gms. of gasoil. Catalyst was not hydrated prior to charging the emulsion.

TABLE 7

Comparison of Catalyst Protection Methods

CATALYST:—Standard Filtrol TCC Catalyst (200 cc)
PRETREATMENT:—5 Hours at 1050° F. 1 V/V/min. bone dry air

Stock 50 cc Charge	ETGO	HGO	ETGO	HGO
TEST	Blank	Rehydration* No Process Steam	Blank	15 Percent Process Steam, No Prehydration
Reactor Temperature	890	900	890	905
Cycle Number	3	22	3	22
Weight Percent Gasoline	39.1	43.2	42.2	42.8
Weight Percent Gas	16.92	16.90	14.6	18.5
Gas Density	1.22	1.20	1.33	1.43
Gas CF/Barrel	536	545	425	500
Weight Percent Carbon	5.0	10.5	4.6	8.7
Weight Percent Conversion	61.8	64.2	57.1	65.1

* Amount of steam sorbed by the catalyst would amount to about 5 percent by weight of the oil charged.

These data show that adequate protection can be provided by 15 percent process steam without the necessity of hydrating before cracking. Actually some benefit is indicated by the gas density changes. Although the amount of process steam necessary is three times as much as with prehydration there is some evidence that the required amount varies with different types of stocks and less poisonous feeds do not need as much steam as shown here. The critical value would have to be determined for each stock. Also the use of process steam in countercurrent TCC operation has the added advantage of releasing the heat of hydration in the cracking zone of the reactor. There are some cases where this additional heat is necessary to reach the desired conversion level.

TABLE 8

Effect of Wet H_2S Without Prehydration

(Catalyst and Pretreatment Same as in Other Tests)

TEST	Blank	Dehydrated Catalyst Exposed to Wet H_2S
Percent 410° F. E. P. Gasoline	40.2	27.5
Weight Percent Gas	5.5	5.1
Gas Density	1.33	0.52
Weight Percent Carbon	4.4	6.2
Carbon Production Factor	1.04	2.40

However, the use of hydration steam before cracking seems to provide greater protection as is indicated by the results in Table 8. In this experiment, the catalyst was not hydrated before exposure at 900° F. to saturated H_2S (H_2S-H_2O mix at 200° F. before preheating). These data should be compared with those in Table 2.

The results show that catalyst was quite severely poisoned as a consequence of omitting the hydration step prior to the exposure to wet H_2S. For this reason, it is recommended that, where possible, the catalyst be rehydrated before the cracking cycle.

Pilot Plant Tests

Laboratory experiments in 200 cc units, such as those used in the studies shown, probably afford the catalyst maximum protection from heat and steam deactivation. Experiments with and without rehydration, and duplicating commercial operating conditions, were carried out by Standard Oil Company (Indiana) in their 2 B/D fluid pilot plant. The data obtained in an early series of runs are shown in Table 9.

TABLE 9

Rehydration of Natural Catalyst in Fluid Pilot Plant

900° F. Reactor 1025° F. Regenerator Equilibrium Clay Catalyst
FEED:—Coke Still Gasoil—1.5 percent Sulfur—Conradson Carbon 0.11
DISTILLATION:—I.B.P., 377° F.—10 Percent, 483° F.—50 Percent, 614° F.—90 Percent 738° F.

HOURS	10¼	22¼	34¼	46¼	58¼	98*
Wt. Percent Rehydration Steam	0.5	0.5	0.5	0.5	0.5	0
Volume Percent Gasoline	41.1	40.9	41.5	39.7	37.8	32.6
Gas CF/Barrel	84.2	83.8	87.3	90.2	92.4	125.1
Weight Percent Carbon	5.2	5.5	5.5	5.6	5.5	6.3
Weight Percent Conversion	50.3	57.4	47.5	50.6	49.4	42.0
Catalyst Activity	23.2	....	....	....	21.5	16.8
Carbon Production Factor	1.33	....	....	....	1.55	2.92
Pounds Sulfur Out Regenerator	0.35	0.35	0.41	0.36	0.34	0.79
Pounds Sulfur Cracked Gas	3.17	3.26	3.34	3.25	3.17	2.55

* 20 hours without rehydration before run started.

The first five columns represent the data taken during twelve hour test periods; the hours refer to the mid point of the run for total hours on stream. After the conclusion of the experiments with rehydration, the hydration steam was cut out for an interval of 20 hours and another test run made. Data for this period are given in the last column of Table 9.

The catalyst was rehydrated by admitting steam near the bottom of the regenerated catalyst standpipe. Catalyst activities and carbon producing factors were obtained by Standard using their own method.

From the pilot plant tests, it will be noted that the gasoline yield and conversion remained relatively constant, and that there was only a slight increase in gas volume and coke make. The activity and carbon producing factors also decreased and increased respectively but by a small amount compared with the changes which occurred for the test

period without hydration. The increase in carbon production factor for this catalyst from 1.55 to 2.92 is especially indicative of sulfur poisoning.

Of particular interest is the change in distribution of sulfur. The total amount of sulfur is approximately the same for all runs being slightly lower for the run at 42 percent conversion (column 6). Without hydration the amount of sulfur passing out with the flue gas is more than double the average amount shown for the runs with hydration. There is a corresponding reduction in the pounds of sulfur in the cracked gas.

If the difference in sulfur distribution is caused by the sorption of sulfur compounds during reaction and subsequent removal during regeneration, the amount of sulfur responsible for the poisoning is 0.02 percent by weight of the catalyst. This would account for the inability to find any physical change in the catalyst deactivated by H_2S or high sulfur gasoil.

It might be pointed out that the data given in all the above tables do not appear to prove definitely that the source of poisoning is from the iron or because of the crystal structure. The presence of 0.2 percent iron sulfide or the destruction of the montmorillonite to a significant degree could be detected by thermal analysis but there is no evidence of either action. More precise experiments will have to be made in order to ascertain the cause of activity loss.

Rehydration Factors

The amount of water necessary to hydrate the catalyst is of some importance since it appears advisable to have enough steam to hydrate the catalyst but not such an excess that there is danger of steam deactivation. In the laboratory fixed bed units an excess of steam was used since the purpose was to prevent sulfur deactivation and conditions of test were not severe enough to make steam deactivation a serious factor. In moving bed or fluid cracking systems the amount of steam used is a cost item and the more severe temperature and pressure conditions may possibly lead to steam deactivation. Higher catalyst makeup rates would of course be required to maintain a given activity if additional steam deactivation occurred.

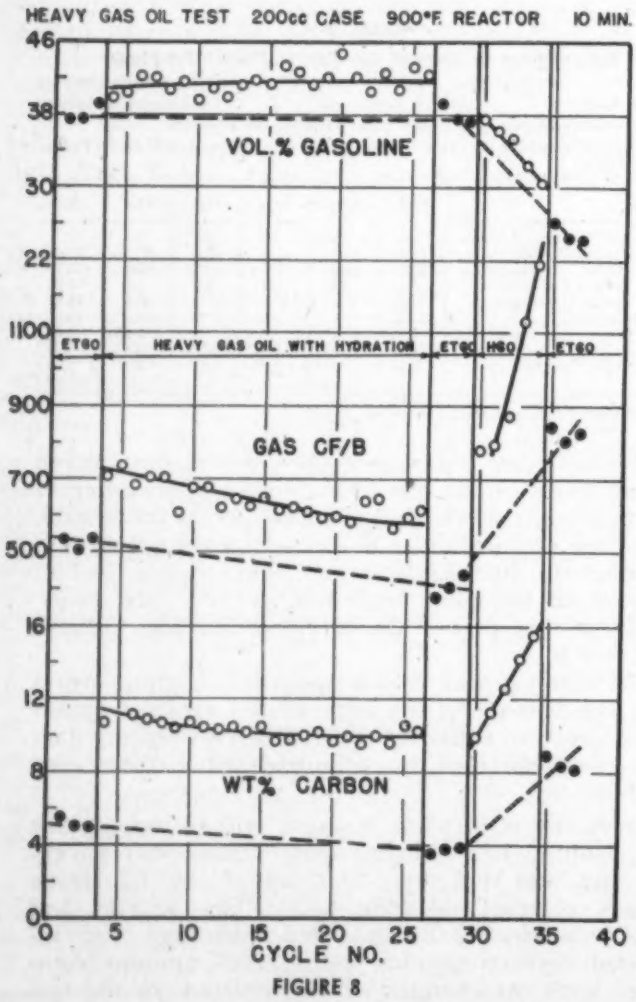

FIGURE 8

In order to estimate the hydration steam requirement the following empirical equation has been used as a guide in setting up initial rates for hydration; adjustments have been made in steam input after the water balances were taken.

$$A = \frac{(1480 - t - e^f)\ 0.004\ S}{394} \qquad (1)$$

where
A = water sorbed, wt.% of catalyst
t = temperature in °F.
S = Surface area m^2/gm by BET method
e = natural logarithm base
$f = \frac{2333\text{-}P}{350}$ where P = pressure in mm abs.

This equation is not absolutely precise but it is believed to represent fairly well the relationship of the variables.

Steam requirements would therefore be:

A X cat rate in lbs. per hour ÷ 100.

However, there are some limitations. Temperature of regenerated catalyst must be about 1050° F. or less in order for it to sorb water. The absolute maximum for significant sorption of steam under any conditions has been established at 1060° F.

Also, it should be pointed out, the above equation does not apply to catalyst which has not been completely dehydrated, i.e., the equation gives the maximum capactiy of the catalyst to sorb moisture at high temperature. This may be explained by reference to the thermal curves in Figure 3. As previously mentioned, increasing the calcination temperature decreases the size of the original hydroxyl deflection. This is compensated for, to some extent, by an increase in the size of the thermal effect corresponding to rehydration. Obviously the hydration capacity will vary in proportion to the amount of the original hydroxyl water which has been driven out of the catalyst.

The length of time required to completely dehydrate natural catalyst is a function of the regenerator temperature. At 1015° F. about 40 percent of the original hydroxyl water still remained in the catalyst after many months of operation. At 1050° F. regenerator temperature a noticeable trace of the hydroxyl water appeared in the equilibrium catalyst. At 1075° F. regenerator temperature about 300 hours were required for total dehydration. All of the above temperatures and times were for fluid unit operation. TCC regenerators usually dehydrate the catalyst and material circulating in these systems may be considered dehydrated.

The reason for this appears to lie in a regeneration temperature in at least one zone of the kiln being above 1075° F. as indicated by the termocouple. After several passes through this zone, the catalyst has been held long enough under conditions which

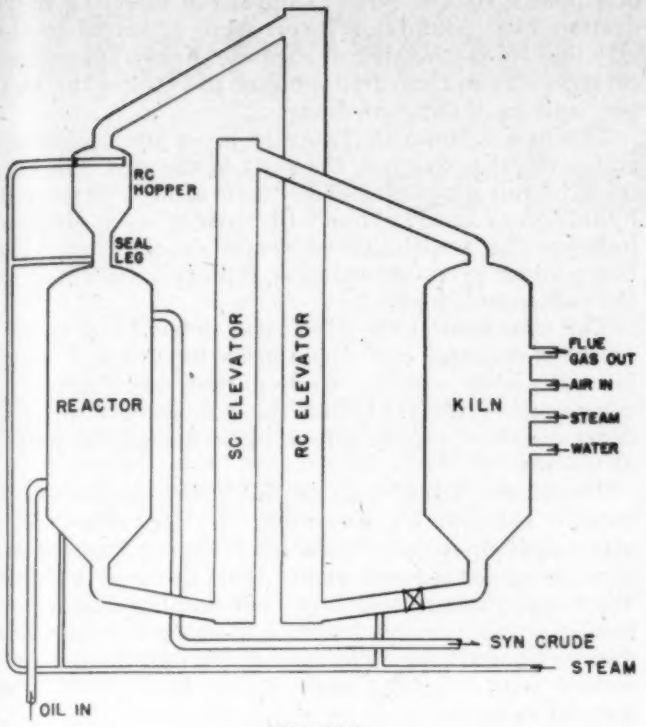

FIGURE 9
TCC Process

are sufficiently severe to effect dehydration. Not many TCC units have been carefully studied but so far no thermal analyses obtained on catalyst from these units have shown the presence of the original hydroxyl water.

Equation 1 shows that sorpotion is dependent on temperature, pressure and surface area. Dependency on the third variable may also be illustrated by means of thermal curves such as those shown in Figure 4. The second curve is for catalyst which has been used approximately 600 hours. The third curve is for catalyst which has reached an equilibrium activity of 22 D+L. The relationship between rehydration capacity and surface area may be illustrated by the tabulation below:

Sample	Rehydration Deflection Area in²	Surface Area m²/gm.
Fresh natural	2.00	290
600 hours use	1.00	175
Equilibrium	0.30	122

There are a number of difficulties which arise in attempting to compute the actual weight percent of steam sorbed by the catalyst during rehydration. In general, however, the amount sorbed in commercial plants is within the range of the value predicted by equation 1 and thermal analysis.

There has been a considerable amount of work done on the revivification of sulfur poisoned natural catalyst. Enough data are available to show that catalyst can be revivified to the point where approximately normal product distribution may be obtained. Discussion of this topic will be reserved for a future article.

Commercial Application

The principle of rehydration has now been applied to a number of commercial catalytic cracking units, both TCC and fluid. In general the results have been in accordance with the anticipations based on laboratory data. Several procedures have been used for rehydrating catalyst in large scale units. These are illustrated by means of the schematic drawings of a TCC and a fluid unit as shown in Figures 9 and 10. For hydration of cataylst in TCC units, steam is admitted into the clay line below the control valve at the bottom of the kiln. Generally some steam is injected into the regenerated catalyst elevator for the purpose of maintaining an atmosphere of steam. Some steam is also admitted to the reactor hopper, and steam should be substituted for seal gas in the seal leg. However it is important that the catalyst be fairly well saturated by the time the catalyst reaches the seal leg or velocities of steam due to sorption by the catalyst may rise above a critical limit and cause holdup in the reactor seal leg.

In the light of recent experience, the best procedure for obtaining complete hydration appears to be by a steam distributing device within the regenerated catalyst hopper bed. Injection of steam may then be dispensed with at the other less efficient points. If it is desirable to obtain at least some of the heat of hydration within the reactor, then the amount of steam put into the hopper is reduced, inert gas is used for seal; and a large amount of process steam is added.

Figure 10 illustrates the essential features of a fluid catalytic cracking unit. If feed is injected at some point as in the sketch, rehydration is fairly successfully carried out by raising the injection steam rates at the end of the reactor feed line below the regenerated catalyst slide valve. However, in the design where the fresh feed is admitted with the injection steam it is necessary to add the hydration steam above and below the regenerated catalyst slide valve. At high catalyst rates, it may be necessary to add steam throughout the length of the regen-

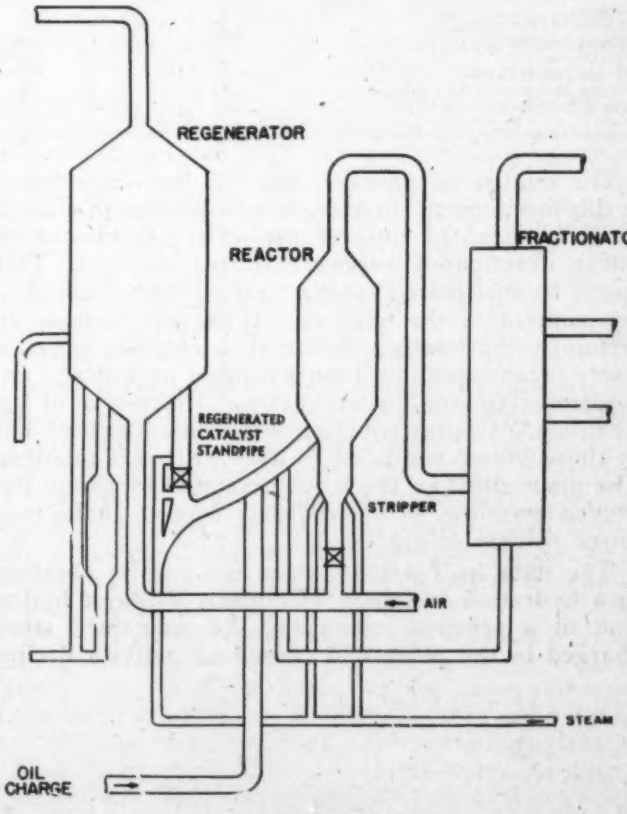

FIGURE 10
Fluid Process

erated catalyst standpipe in order to admit a sufficient quantity and obtain adequate distribution. Addition of steam in the regenerated catalyst standpipe also reduces the possibility of erosion which tends to occur with high injection steam rates.

Rehydration has been practiced to some extent in a number of fluid units. The amount of steam which could be admitted to the regenerated catalyst standpipe was much less than that which is known to be necessary for complete rehydration. In those cases where steam injection rates were raised to hydrate the catalyst there was some question about the efficiency of mixing. Nevertheless, operators reported improved product distribution, particularly reduced carbon laydown and reduced hydrogen in the gas.

Detailed analyses with suitable corrections for changes in feed stock, variations in operating conditions, etc., have not been made so that it is not possible to be certain of the exact amount which the yields changed. However, coke yields have dropped, more than 1 percent in some cases, gasoline yield increased up to about 2 percent and dry gas has decreased up to 0.5 percent. Although the weight percent change in dry gas has not been large, the volume handled is reduced because of the large reduction in hydrogen content. Further runs, in which adequate facilities have been installed for more effective hydration and the necessary test periods made, will provide more quantitative data.

TABLE 10
Rehydration in TCC Unit

	1	2	3
	Start	Before Sour Feed 6 Days Steam	After 21 Days Sour Feed
Catalyst Temperature, °F.	880	892	860
Feed Rate B/D	10855	10428	10046
Conversion	42.9	41.2	42.5
Cat A-410° F., E.P. Gasoline	30.2	30.6	29.7
Weight Percent Gas	3.06	3.46	3.09
Gas Density	1.22	1.29	1.20
Weight Percent Carbon	1.86	1.77	1.65
Carbon Production Factor—approximate	1.16	1.08	1.07
Make up Rate Percent Inventory	1.27	1.04	1.39

The quality of gasoline has not been mentioned in this discussion. There is some indication of change in distribution of unsaturates when cracking with sulfur deactivated versus hydrated catalyst. This might be anticipated, owing to the change in hydrogen content of the fixed gas. However, there is no certainty that sulfur deactivated catalyst gives a lower octane gasoline than hydrated or average uncontaminated equilibrium catalyst. Discussion of the treatment of sulfur containing gasoline has been left to those better equipped to deal with this problem. The main effort in the work here was to obtain improved gasoline yield, reduced carbon make and lower volume of gas.

The data in Table 10 show the results obtained in a hydration test in a TCC unit. Without hydration in a previous operation, the sour feed stock charged in the plant had caused an activity decline of 7 points, by Cat A, in 11 days. For effecting rehydration 2400 pounds of steam were admitted in the clay line below the kiln, at the base of the regenerated catalyst elevator, a small amount to blanket the hopper, and as sealing medium.

The first column in Table 10 gives the conditions and catalyst activity at the start of the run. The second column gives the data taken after 6 days with hydration of catalyst but with "sweet" feed stock to indicate the possibility of steam deactivation. The last column gives the catalyst activity after charging the poisonous gasoil.

The sour feed stock which was detrimental in previous operations can apparently be cracked satisfactorily with catalyst in hydrated condition. The constancy of the CPF and the gas density are evidence that no poisoning took place during the period of the test.

The above tabulations showing the protection of natural catalyst by hydration in laboratory, pilot plant and plant operations have been confirmed by other laboratories and plants than those given here. There are numerous operational details which have been omitted owing to the lack of space but the above discussion outlines the more important points connected with cracking high sulfur feed stocks over natural catalyst.

Conclusion

The relationship between the crystal structure of montmorillonite catalyst and the phenomenon of rehydration have been shown. The importance of rehydrating catalyst before cracking high sulfur stocks and general procedures for accomplishing this have been tabulated and discussed. Some commercial data are given which confirm the laboratory findings and it may be stated that cracking of high sulfur stocks with natural catalyst is feasible if the catalyst is kept in a hydrated state.

Acknowledgment

The thermal analyses shown in Figure 3 were made by Dr. R. E. Grim of the Illinois State Geologic Survey. We are indebted to The Pure Oil Company for the data in Table 10 and we wish to thank Dr. N. Fragen and his associates at Standard Oil Company (Indiana) for verifying, on pilot plant scale, the findings from laboratory experiments on rehydration; the data in Table 9 were obtained at the Standard Oil Company laboratories. We also wish to thank Union Oil Company for supplying the coker gasoil from Santa Maria crude.

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Forty Years of Automotive Gear Lubrication

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FORTY years have produced many changes and plenty of grief during that time for lubricating technologists and automotive engineers. Gear lubrication, both in the transmission and differentials were no problem 40 years ago nor even 30 years ago.

A straight reduced steam cylinder oil was used on cars that were equipped with transmission and rear axle gears, and practically no cars were in operation at that time during the winter months in the northern and mid-western states, due to poor roads and poorly paved brick streets.

Several years later, one compounder produced a heavy transmission grease using a soda-base soap and a 150 viscosity Pennsylvania steam-refined cylinder oil. This grease was used in the transmission not only as a lubricant but to quiet the gears, allowing the gears to break down the fiber grease into a heavy cream. As cars and trucks became more into general use, a heavy compounded oil was used for the lubrication of the gears in the transmission and differential.

Spiral bevel gears were a great improvement over the straight bevel gears first used, and a compounded mineral oil containing some lead soap and sulphur was introduced and used with satisfactory results.

Testing Equipment

With increasing use of cars and trucks as a year round necessity, it became imperative for the manufacturers of lubricants to install suitable testing equipment. One of the first machines used for research and testing, consisted of an automotive rear axle connected to an electric motor by means of a reduction gear and universal joint. The rear axle assembly was installed in an insulated cabinet provided with refrigerating coils to chill the whole assembly to minus 20° F., as well as with an electric element to heat the cabinet to 180° F. On the outside of the cabinet, one of the axle ends was provided with a Prony brake to apply the load and a double glass top on the cabinet itself, allowed the operator to observe the action of the lubricant through a cutaway in the upper back-end housing of the rear axle. Notations were made as to channeling at low temperatures, adhesion and amount of lubricant on the gears and between the pinion and ring gear. The tests were fairly representative as to the conditions encountered in actual service.

A great many lubricants were tested before satisfactory products were obtained that would meet not only the high and low temperature conditions in the rear axle but such physical tests as film strength, oven stability, corrosion, and other tests. Large diameter gears were the most difficult to lubricate and required compounded gear lubricant consisting of a small percentage of soda-base soap, in a mineral oil which contained about 1 percent active sulphur and some lead oleate. The small percentage of soap in an 84-90 SUS/210° F. black oil, or in a mixture of Mid-Continent black oil of 90-95 SUS/210° F. was used to produce a more adhesive product; the lead soap to prevent wear and to lower the coefficient of friction; the sulphur to protect the gears from scoring, galling, or, in extreme cases, welding.

Commercial Gear Lubricants

When fluid greases are made by adding small percentages of soap or other thickening ingredients to oil, the viscosity number by which the lubricants are classified is determined from the viscosity of the oil at 100° F., at 210° F., and at 0° F., before the addition of the soap or other thickening ingredients. Some of the early commercial gear lubricants were manufactured in three grades: one for summer use, and two for winter use, as shown in the tabulation, Table 1.

The small percentage of soap used, especially in the commercial gear lubricants, produced better adhesiveness to the metals and greatly assisted in cushioning of the gears (sliding action and shock loading).

Shortly after the introduction of these commercial gear lubricants, five "extreme pressure" gear lubricants, SAE 80-90-110-160 and 250 grades, were put on the market. The simplified SAE gear lubricant classification reduced these five grades to four grades—SAE 80-90-140 and 250, with the following specifications:

Viscosity Number	Viscosity Range SUS	Consistency—Must not channel in service at ° F.
SAE 80	100,000 sec. at 0° F. maximum	—20
SAE 90	800-1500 sec. at 100° F.	—0
SAE 140	120-200 sec. at 210° F.	+35
SAE 250	200 sec. at 210° F. minimum	——

Some of these early SAE 80 and 90 grades contained a small percentage of aluminum stearate soap (1½ percent), in a low pour mineral oil of 80-85 SUS/210° F. for the 80 grade, and 95-100 SUS/210° F. for the SAE 90 grade. A small percentage of sodium soap (2¼ percent) was incorporated into a 200 SUS/210° F. oil for the SAE 140 grade, and a 220-300 SUS/210° F. oil with (2.75 percent) sodium soap was used for the SAE 250 grade.

These lubricants were first manufactured with an "active" sulphur as a film strength agent, or what is known as the lead-soap active sulphur type, and were quite corrosive to a copper strip. The active sulphur was replaced with a special sulphur-chloride base as a component, and the new products were less corrosive to copper and non-corrosive to steel. When compounded with this special S_2Cl_2 base, the final viscosities were 98 SUS/210° F., 103 SUS/210° F., 250

SUS/210° F. and 321 SUS/210° F. respectively. These lubricants also contained 1 percent lead oleate.

Tests at that time with Aleman's machine, showed that the flour of sulphur or lard-sulphur bases were less satisfactory than sulphur-chloride or sulphur-chlorinated products, such as an 84 percent Pennsylvania or Mid-Continent oil having a viscosity of 95 SUS/210° F. combined with 3 to 4 percent heat treated castor oil and 12 percent sulphur-chlorinated base. Results of these tests showed that the speed of the testing machine is very important, as most any lubricant of this type will pass 100 or 200 rpm but may fail on the 400 or 600 rpm test. The 600 rpm test on the Aleman machine represents a rubbing speed of 30 feet per minute. The best lubricant tested in this machine consisted of an oil having a viscosiety of 90

Above, right, is shown a 1908 "gearless" Metz automobile equipped with a two-cylinder opposed-horizontal air-cooled motor; friction-drive (aluminum disc against a leather-faced disc) and side chain drive to rear wheels. Assembled and driven by the author.

Below is shown a prospective 1948 "gearless" (Tucker) rear-engine drive automobile, prestone cooled, without the conventional transmission, clutch, drive shaft and torque tube, full-width rear axle and conventional differential.

SUS/210° F. and contained some of these sulphur-chlorinated bases.

The mono-sulphur chloride base, when properly made, shows only a slight stain on a polished copper strip when its reaction is complete, while a compound containing free chlorine is bound to be more corrosive, depending on how the chlorine is added. Some compounders combine the chlorine directly with specifically chosen mineral oil fractions, while others chlorinate the fats or the combined fat and mineral oil. It has been shown that these chlorinated products also assist in breaking up or dissolving any small amount of amorphous wax left in the oil and thereby lowers the flow characteristics of the lubricant.

The S_2Cl_2 base used in these lubricants was made from a combination of lard oil, a South Texas pale oil (1200 SUS/100° F.), and 10 percent of a mono-sulphur chloride. Special kettles and other equipment are necessary for its manufacture and are usually found only in large chemical manufacturing plants. The finished product is a bright, ruby colored, syrupy material, soluble in all proportions in mineral oil, and produces a high viscosity index in mineral oils. When 90 percent of a low viscosity South Texas oil, having a V.I. of about 50 or less, is compounded with 10 percent of this base, a V.I. of 113 results, and a film strength of 25,000 pounds on the Moughey machine, which is equal to the present SAE 790 rpm of about 245 pounds. When used in E. P. gear lubricants, 12 to 15 percent of this base also produced a 25,000-pound film strength and when the test was continued with a 5000-pound load for one hour, the load could again be increased to 25,000 pounds with very little increase in the bath temperature. The steel test pin (1 inch by 4 inches) and the steel bushings were usually 100 percent perfect, while most of the

Commercial Gear Lubricants

GRADE	Summer	Winter	X Winter
Percent Sodium Soap.	2.64 Percent	1.62 Percent	1.59 Percent
Mineral Oil (SUS)....	200/210° F.	95/210° F.	80/210° F.
	5280/100° F.	1330-1600/100° F.	950-1100/100° F.
	(500-600 Furol/100°F.)	500,000/0° F.	200,000/0° F.
Pour Point.....	+20° F.	—10° F.	—10° F.
Vis. Index.....	78	81	85.4
Mineral Oils Used....	97.36 Percent Mid-Cont. & So. Texas oils	91.38 Percent Smack-over oil 7.00 Percent So. Texas pale	98.4 Percent Smack-over oil
Cadillac rear axle test.	O.K. at +20° F.	O.K. at —4° F.	O.K. at —10° F.
Completely Flushed Over Gears.....	At +35° F. in 30'	at +28° F. in 25'	at +20° F. in 20'
Channel Test.....	+20° F. to +35° F.	—0° F. to +25° F.	—15° F. to +15° F.

other E. P. gear lubricants tested, increased the bath temperature considerably, smoking badly and failed (seized or scored) as the load was increased. This practical testing machine may not have been as elaborate as some of the present equipment, but the results obtained from these tests were of great value to the technologists in perfecting these lubricants and gave the control operator a simple check on all batches manufactured.

The early lead soap gear lubricants when used in connection with chlorinated bases did not show up very well. It appears that the lead oleate and chlorine are not very compatible, and that lead naphthenates are better adapted for this purpose. First, they do not increase the consistency at the lower temperatures, as do some of the lead oleates. Second, they are more compatible with the active sulphur in the lubricants and assist in building-up film strength, especially when used in connection with a sulphurized fatty oil base. The result is better adhesion and reduced friction, especially on steel-to-steel worm gears, or steel-on-bronze and other types of gearing. Used in moderate proportions, the lead naphthenates do not effect the stability of the product, but some of the lead oleates will precipitate a small amount of lead when the lubricant is used above 180° F. Most lead soaps are insoluble in petroleum oils unless chemically combined. Any excess of lead is precipitated or combines with sulphur to form lead sulfide.

These mild E. P. gear lubricants were satisfactory for the spiral bevel gears at —20° F. and up to 200° F. or better, but, when subjected to the Gleason test for Hypoid gears, they failed due to insufficient sulphur in the finished product. The high oiliness and high V.I. produced by the S_2Cl_2 base were not sufficient to pass the test. An SAE 90 Gear lubricant that passed the Gleason test, was made from a 90 SUS/210° F. Pennsylvania oil, containing 6 percent

lead oleate; 5 percent heated castor oil; and 16 percent S_2Cl_2 base. The analysis of the finished oil showed 2.64 percent sulphur and 1.09 percent chlorine. Corrosion (3 hours at 210° F.) was satisfactory and the Timken permissible load was 33 pounds.

Film Strength Machines

Various film strength machines for testing gear lubricants and gear oils have been used, such as: the Gleason test; the SAE machines; the Timken machine; the Faville-LaVallee; the Moughey; the Aleman; the Floyd and the Four-Ball machine. Other testing machines necessary to investigate various physical properties of gear lubricants are: Channel test; Adherometer test; Oven stability test; Corrosion test; McMicheal test; N. L. G. I's pressure viscosity test; Knopf's Consadometer; laboratory rear axle and transmission tests and actual service tests in passenger cars and trucks.

Sulphur properly incorporated in the mineral oil was, up to now, the only satisfactory element to prevent scored or scuffed gears, but since it is impossible for the mineral oil to absorb more than 1 to 1½ percent of sulphur, any greater amount added will be free in the lubricant and will settle out eventually. Other additives, such as a small amount of lead naphthenate, chlorine or phosphorus, et cetera, have been incorporated to produce the desired results. A mineral oil containing 1 to 1½ percent of "natural sulphur" which is neutral to copper, does not produce an increase in film strength when such an oil is used in gear lubricants. Fixed oils, especially the lard oils, will absorb as high as 12 percent sulphur without showing any stain on the copper strip and some of these lard-sulphur bases are used to meet sulphur specifications calling for more than 1.50 percent of sulphur. Chlorine alone in a mineral oil shows a better film strength than the lead soaps but is too corrosive to the axle housing.

With demand for lower cars and higher speeds (lower center of gravity and smaller diameter wheels), automotive engineers developed hypoid axles. It was found that a passenger car hypoid gear axle operates under the most severe lubrication conditions at high speed, while a heavy-duty truck hypoid axle operates under the most severe lubrication conditions at low speed with maximum engine torque in low gear.

Early application of hypoid gears were not properly designed. The gears were not cut exactly true to obtain the lowest possible sliding friction and pressure, nor were they properly aligned in application, and excessive sliding friction, high local pressures, wear and overheating resulted. Under these faulty mechanical conditions, the newly developed hypoid gear lubricants had not only to lubricate these gears but had to overcome mechanical defects, which no lubricant is able to accomplish. These hypoid gear lubricants and the newer E. P. gear oils (without soap) were produced to meet the ever increasing speed and were satisfactory because the ring gear diameters were considerably reduced over the originals used.

It was soon recognized that the only real test of a hypoid lubricant is its ability to lubricate the axle under actual service conditions, and consequently a severe test schedule was established. The present all-year hypoid gear lubricants have components of various chemicals incorporated into the mineral oil. The SAE 80 and SAE 90 grades were made from sulphurized oils containing about 1.36 percent sulphur and 0.75 percent chlorine in the finished product, with 5 percent special lead naphthenate. The finished SAE 80 grade had a viscosity of 98 SUS/210° F. and 62,000 SUS/0° F., a pour point of minus 10° F. and an SAE film strength at 790 and 1000 rpm of 580 pounds on both speeds. The SAE 90 grade contained a sulphurized Pennsylvania oil containing 1.80 percent sulphur and 5 percent special lead naphthenate. The finished product had a viscosity of 135 SUS/210° F., 1570 SUS/100° F., and 200,000 SUS/0° F., with a film strength of 580 pounds on both speeds. These lubricants seemed satisfactory for both passenger car and truck hypoid real axles.

Some of the newer hypoid gear lubricants have only sulphur, chlorine, and a small amount of phosphorus.* The mild sulphur-chloride base hypoid and E. P. gear lubricants produced Timken loads of from 30 to 43 pounds while some hypoid gear lubricants went as high as 73 pounds on the Timken load. The four hypoid gear lubricants shown in Dr. Prutton's article are as follows:

1. A combination of 0.78 percent lead soap, 2.8 percent sulphur, and 1.0 percent chlorine which shows 69 pounds on the Timken machine. This lubricant passed the low speed high torque axle test, but showed erratic results on the SAE film strength machine at 1000 rpm.
2. A combination of 3.2 percent chlorine and 0.8 percent sulphur showed 33 pounds on the Timken machine and failed on the low speed high torque axle test.
3. A combination of 1.2 percent sulphur; 0.4 percent chlorine and 0.04 per cent phosphorus also showed a Timken load of 33 pounds but passed the low speed high torque axle test, no doubt because of the incorporation of a small amount of phosphorus.
4. A combination of 1.5 percent sulphur and 0.04 percent phosphorus passed the low speed high torque axle test and had a Timken load of 51 pounds and an SAE film strength of only 70 pounds at 1000 rpm.

   The highest SAE film strength test of the four lubricants shown, was the combination of 3.2 percent chlorine and 0.8 percent sulphur which showed 320 pounds at 1000 rpm on the SAE machine, yet failed at the low speed high torque axle test, while the 1.2 percent sulphur; 0.4 percent chlorine and 0.04 percent phosphorus combination had an SAE load of only 250 pounds at 1000 rpm and passed the low speed high torque axle test, which again must be due to the small amount of phosphorus used.

The high speed axle test was satisfactory on all four lubricants. No corrosion test was included in the analysis. According to the latest data, if a small percentage of phosphorus is incorporated into the chlorine-sulphur type gear lubricants, it will produce a satisfactory and acceptable product.

To produce a very stable product, it might be well to investigate the new fluorine compounds which in connection with other ingredients may produce a gear lubricant of high resistance to heat and one that is less corrosive than the present lubricants. Major specifications on these hypoid gear lubricants are: Full-scale axle tests, such as the Gleason test; shock loading at high speeds; and the 30-hour high torque low speed test. (U. S. Army Specifications 2-105B.)

* Dr. C. F. Prutton—Steel, March 31st, 1947.

Relationship of Reflux to Feed for a Fractionating Column

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THERE are three methods which have been used in the past to express reflux ratio on a fractionating column. These are: (1) the fundamental or the ratio of the mols of liquid descending to the mols of vapor rising, (2) the ratio of liquid descending to the overhead product, and (3) the ratio of liquid descending to the feed. The first two of these have been widely discussed in the literature, however, to the author's knowledge, no publication concerning the latter ratio has ever appeared.

NOMENCLATURE

A = more volatile assumed component
B = less volatile assumed component
α = relative volatility—in this paper of component A to B
Xad = mol fraction of A in distillate
Xaf = mol fraction of A in feed (liquid, mixed or vapor phase)
Xaw = mol fraction of A in bottoms
Xbd = mol fraction of B in distillate
Xbf = mol fraction of B in feed (liquid, mixed or vapor phase)
Xbw = mol fraction of B in bottoms
$p = \frac{\overline{L}-L}{F}$
Nm = minimum number of plates in column (reboiler assumed to be a perfect plate and not included)
N = number of plates in column (reboiler not included)
Nc = number of plates determined from curves
Lmin = amount of minimum required reflux
L = amount of operating reflux
D = amount of overhead
F = amount of feed
$\overline{L}$ = amount of feed
$\overline{V}$ = amount of vapor rising in column below feed
V = amount of vapor rising in column above feed
J&J$_m$ = factors used by Brown and Martin

Calculations On Assumed Systems

Since many commercial columns with the same number of plates and making the same separation appeared to be operating at nearly similar ratios of reflux to feed, it seemed worth while to investigate this matter more extensively by making detailed calculations on several assumed systems. If such a simple relationship as mentioned above did exist it would

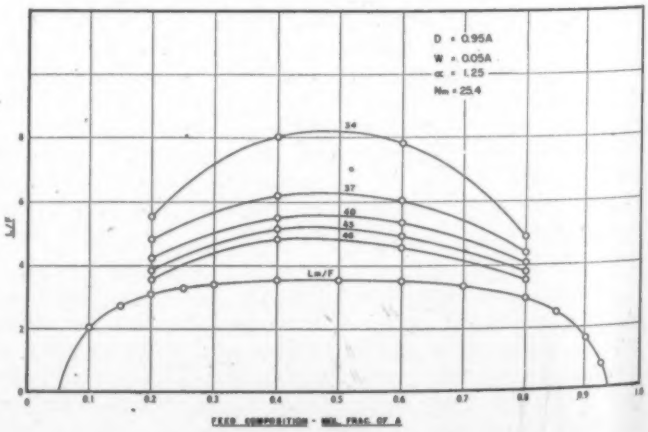

FIGURE 1

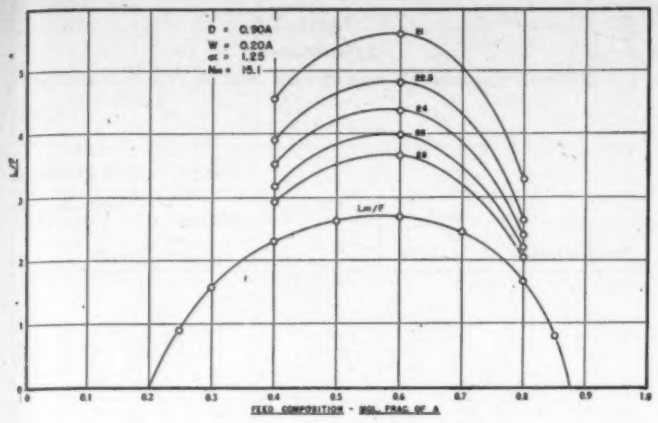

FIGURE 2

be of great aid to the designer and the plant operator. The following separations were assumed and calculated by the graphical method of McCabe-Thiele[8] for various reflux ratios. The usual simplifying assumptions of adiabatic operation and equal molal heats of vaporization were naturally included in these calculations.

Separation No.	Relative Volatility A to B	Feed Composition Mol. Frac.	Overhead Composition Mol. Frac.	Bottom Composition Mol. Frac.	Feed Condition
1.....	1.25	0.80A 0.20B	0.95A 0.05B	0.05A 0.95B	Sat. Liq. Sat. Liq.
	1.25	0.60A 0.40B	0.95A 0.05B	0.05A 0.95B	Sat. Liq. Sat. Liq.
	1.25	0.40A 0.60B	0.95A 0.05B	0.05A 0.95B	Sat. Liq. Sat. Liq.
	1.25	0.20A 0.80B	0.95A 0.05B	0.05A 0.95A	Sat. Liq. Sat. Liq.
2.....	1.25	0.80A 0.20B	0.90A 0.10B	0.20A 0.80B	Sat. Liq. Sat. Liq.
	1.25	0.60A 0.40B	0.90A 0.10B	0.20A 0.80B	Sat. Liq. Sat. Liq.
	1.25	0.40A 0.60B	0.90A 0.10B	0.20A 0.80B	Sat. Liq. Sat. Liq.
3.....	1.25	0.60A 0.40B	0.80A 0.20B	0.10A 0.90B	Sat. Liq. Sat. Liq.
	1.25	0.40A 0.60B	0.80A 0.20B	0.10A 0.90B	Sat. Liq. Sat. Liq.
	1.25	0.20A 0.80B	0.80A 0.20B	0.10A 0.90B	Sat. Liq. Sat. Liq.
4.....	1.75	0.80A 0.20B	0.90A 0.10B	0.10A 0.90B	Sat. Liq. Sat. Liq.
	1.75	0.60A 0.40B	0.90A 0.10B	0.10A 0.90B	Sat. Liq. Sat. Liq.
	1.75	0.40A 0.60B	0.90A 0.10B	0.10A 0.90B	Sat. Liq. Sat. Liq.
	1.75	0.20A 0.80B	0.90A 0.10B	0.10A 0.90B	Sat. Liq. Sat. Liq.
5.....	1.50	0.80A 0.20B	0.90A 0.10B	0.10A 0.90B	Sat. Liq. Sat. Liq.
	1.50	0.60A 0.40B	0.90A 0.10B	0.10A 0.90B	Sat. Liq. Sat. Liq.
	1.50	0.40A 0.60B	0.90A 0.10B	0.10A 0.90B	Sat. Liq. Sat. Liq.
	1.50	0.20A 0.80B	0.90A 0.10B	0.10A 0.90B	Sat. Liq. Sat. Liq.
6.....	1.25	0.80A 0.20B	0.95A 0.05B	0.05A 0.95B	Sat. Vap. Sat. Vap.
	1.25	0.60A 0.40B	0.95A 0.05B	0.05A 0.95B	Sat. Vap. Sat. Vap.
	1.25	0.40A 0.60B	0.95A 0.05B	0.05A 0.95B	Sat. Vap. Sat. Vap.
	1.25	0.20A 0.80B	0.95A 0.05B	0.05A 0.95B	Sat. Vap. Sat. Vap.

A total of 121 diagrams were made.

Mathematical formulae were used to determine minimum reflux rather than to rely on graphical interpretation for this value. For the cases of liquid feed at the boiling point, Fenske's formula[5] was used to determine minimum reflux whereas for the case of saturated vapor feed, Underwood's formula[10] was used. Underwood's formula is identical to Fenske's when $p = -1$, which is the situation for saturated liquid feed.

These formulae are:

Fenske's Formula

$$\frac{Lmin}{D} = \frac{1}{\alpha - 1}\left(\frac{Xad}{Xaf} - \alpha\frac{Xbd}{Xbf}\right)$$

Underwood's Formula

$$\alpha = \frac{\left(\frac{Lmin}{D} + 1\right) Xaf - (1 + p)\, Xad}{\left(\frac{Lmin}{D} + 1\right) Xbf - (1 + p)\, Xbd} = \frac{Xaf\left(\frac{Lmin}{D}\right) - p\, Xad}{Xbf\left(\frac{Lmin}{D}\right) - pXbd}$$

An explanation of the nomenclature appears at the end of this article.

Both of these formulae give exact answers for binary systems, but would be in error for multicomponent systems (unless the feed plate compositions were known) since in their derivation it was assumed what is essentially that at minimum reflux, the mol fraction of a component in the plate above the feed is the same as the mol fraction of that component in the feed.

The number of theoretical plates obtained from the McCabe-Thiele diagrams were then plotted against reflux ratio so that for various feed compositions, the reflux ratio at the required number of plates could be determined. The reboiler was not counted as a plate. Neither was a tray efficiency assumed which would have a slight effect upon the results presented.

Figure 1 is a plot of the function L/F (reflux to feed) versus the mol fraction of the more volatile component (A) in the feed for separation 1 above. The numbers of theoretical plates are plotted as parameters. In all cases, the mol ratio L/F is used, but a volume ratio could be employed with negligible difference. It can be observed that as the reflux is increased or as the number of plates approach the minimum, the variation from a straight line becomes greater. At total reflux, however, there would be a straight line at an infinite L/F value. This can be

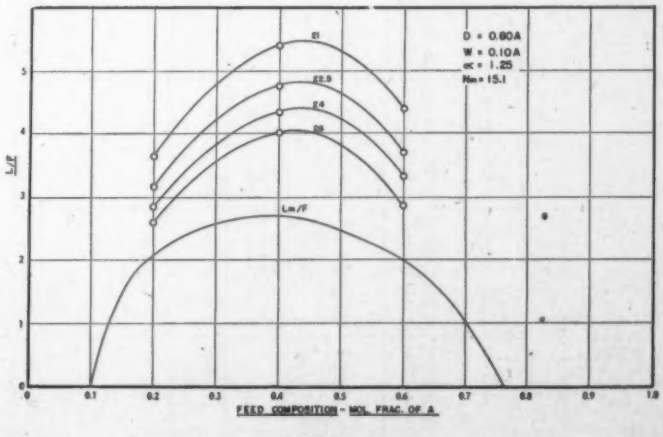

FIGURE 3

readily concluded from Fenske's formula[5] for minimum plates.

$$N_m + 1 = \frac{\log\left(\frac{Xad}{Xbd} \times \frac{Xbw}{Xaw}\right)}{\log \alpha}$$

Figures 2 and 3 are plots for less sharp separations and show that the deviations from a straight line are even greater. For separations 1 and 2, the ratios L/F and L/D are compared with each other in Table 1.

TABLE 1

Comparison of Reflux Ratios

	SEPARATION 1 43 PLATES			SEPARATION 2 28 Plates	
Feed Comp.	L/F	L/D	Feed Comp.	L/F	L/D
0.80A	3.73	4.48	0.80A	2.09	2.44
0.60A	4.92	8.05	0.60A	3.69	6.46
0.40A	5.15	13.2	0.40A	2.96	10.4
0.20A	3.84	23.0			

Figures 4 and 5 are comparable separations for relative volatilities of 1.50 and 1.75 and show the effect of relative volatility on the ratio L/F. For example, at a feed composition of 0.60A, at fourteen plates the ratios L/F are 3.05 and 1.21 for relative volatilities of 1.50 and 1.75, respectively. In order to determine the effect of feed condition on the relationship, calculations were made for separation 1 in which a saturated vapor feed was assumed. These results are plotted in Figure 6 and compared in Figure 7 with the saturated liquid feed results.

The reflux required is greater for vapor feed than for liquid feed but did not have as pronounced an effect as changing the relative volatility in separations 4 and 5. Thus, columns in commercial operation with different relative volatilities should show variances in their reflux to feed ratios, and also for the same system, the L/F value should not change to a great extent if liquid feed conditions are compared with those of vapor feed.

TABLE 2

Separation 1

Gilliland Logarithmic and Brown and Martin Correlations

α=1.25 D=0.95A W=0.05A

N_m=25.4

			PERCENT DEVIATION			
			Gilliland		Brown and Martin	
FEED COMP.	L/D	N	+	−	+	−
0.80A	3.50	∞				
	4.38	44.0		9.5		9.8
	4.90	39.6		9.4		10.4
	5.60	35.0		11.6		13.8
	6.30	33.0		11.3		13.8
	7.00	32.0		9.6		12.8
	8.40	31.5		5.4		8.7
0.60A	5.71	∞				
	7.14	48.0	1.3			1.6
	7.99	43.2	1.6			2.3
	9.14	38.7		0.5		4.7
	10.3	36.3		0.5		5.2
	11.4	35.0	0.6			4.6
	13.7	33.5	1.8			2.9
0.40A	9.07	∞				
	11.3	50.8	8.1		4.1	
	12.7	45.0	8.1		1.8	
	14.5	39.1	1.8			3.7
	16.3	36.6	1.9			4.4
	18.1	35.2	2.0			4.1
	21.8	33.6	3.4			2.6
0.20A	18.7	∞				
	23.3	42.4		8.0		13.1
	26.2	39.2		5.8		11.3
	29.9	36.1		4.5		11.1
	33.6	33.6		5.9		12.3
	37.4	31.5		7.9		14.2

TABLE 3

Separation 2

Gilliland Logarithmic and Brown and Martin Correlations

α=1.25 D=0.90A W=0.20A

N_m=15.1

			PERCENT DEVIATION			
			Gilliland		Brown and Martin	
FEED COMP.	L/D	N	+	−	+	−
0.80A	2.00	∞				
	2.50	27.2		9.3		6.2
	2.80	24.2		11.4		8.0
	3.20	22.2		9.8		8.3
	3.60	21.5		6.5		5.7
	4.00	20.8		5.5		4.6
	4.80	19.7		3.9		3.9
0.60A	4.75	∞				
	5.94	29.9	3.8		3.1	
	6.65	27.2	5.4		3.4	
	7.60	24.4	4.3		0.8	
	8.55	22.4	1.8			1.8
	9.50	21.3	1.4			2.3
	11.4	20.4	3.0			0.5
0.40A	8.16	∞				
	10.2	28.6	1.1			1.4
	11.4	25.6	0.8			2.7
	13.1	23.2		0.9		4.1
	14.7	21.8	0.5			4.4
	16.3	20.9	1.0			4.1
	19.6	19.6	0.5			4.4

TABLE 4

Separation 3

Gilliland Logarithmic and Brown and Martin Correlations

α=1.25 D=0.80A W=0.10A

N_m=15.1

			PERCENT DEVIATION			
			Gilliland		Brown and Martin	
FEED COMP.	L/D	N	+	−	+	−
0.60A	2.83	∞				
	3.54	30.5	3.7		5.2	
	3.96	27.2	3.0		3.4	
	4.53	24.5	2.1		1.2	
	5.10	22.7	0.9			0.4
	5.66	21.6	0.5			0.9
	6.79	20.4	1.5			0.5
0.40A	6.34	∞				
	7.93	32.7	18.7		12.8	
	8.88	27.6	8.7		4.9	
	10.2	24.0	3.4			0.8
	11.4	22.1	1.4			3.1
	12.7	20.9	0.5			4.1
	15.2	19.6	0.0			4.4
0.20A	14.7	∞				
	18.4	25.7		7.6		11.4
	20.6	23.5		6.0		10.6
	23.6	21.7		4.4		10.3
	26.6	20.7		3.3		9.2
	29.5	20.0		2.4		8.3
	35.4	18.8		3.1		8.3

The reflux to feed ratios for various separations at minimum reflux are plotted in Figure 8. For the theoretical case of 100 percent recovery of products and saturated liquid feed, the ratio Lmin/F is $1/\alpha - 1$ for any feed composition (except 0 and 100 percent A). Since this separation would be obtainable only with an infinite number of plates, $1/\alpha - 1$ is the maximum value of Lmin/F for a saturated liquid feed. The deviation from this value becomes greater as the purities of products decrease. For saturated vapor feed, the maximum Lmin/F ratio was found to be $((1/\alpha - 1) + Xbf)$. A linear relationship was not found to exist for other degrees of feed heating. However, Lmin/F would be less than $1/\alpha - 1$ for subcooled liquid feeds, between $1/\alpha - 1$ and $(1/\alpha - 1) + Xbf$ for partially vaporized feeds, and greater than $((1/\alpha - 1) + Xbf)$ for superheated vapor feeds. Mathe-

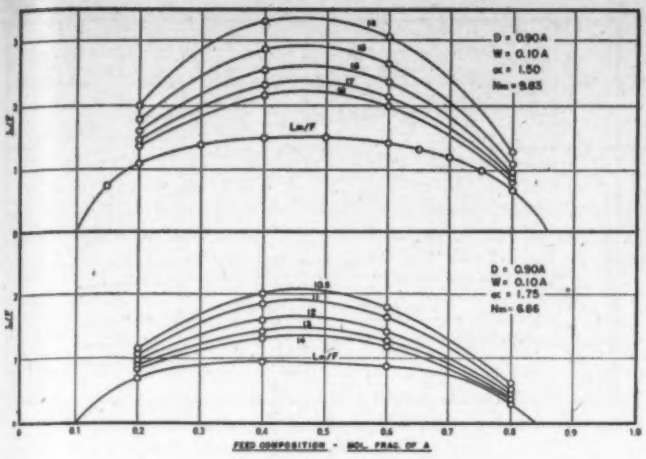

FIGURE 4—(Upper Half)

FIGURE 5—(Lower Half)

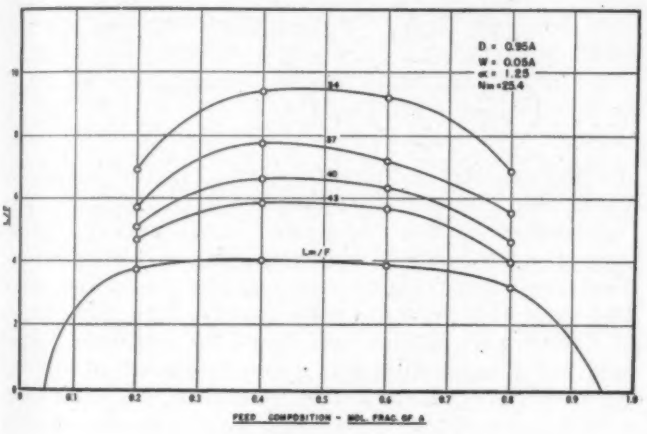

FIGURE 6

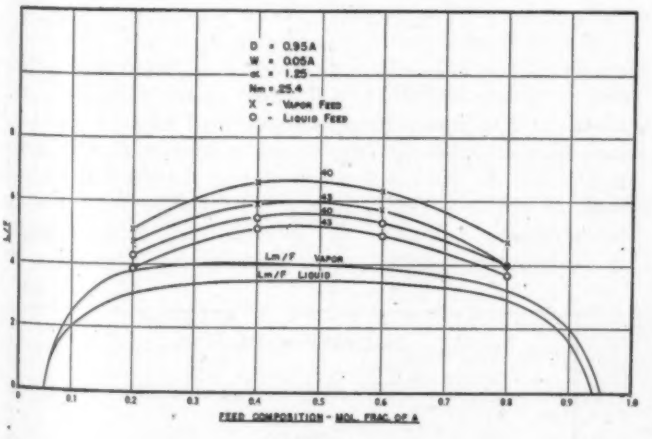

FIGURE 7

matical formulae for each of these cases were not fully investigated. In the case of adjacent key components in multicomponent distillation, the above would also represent maximums if the components heavier than the heavy key were used in determining the value Xbf. For cases with intermediate components between the keys, these formulae would not necessarily represent maximums. A wide variation may be observed in the reflux to feed values of Figure 8 where Lmin/F has been calculated for different cases.

For the designer then, this rule of thumb should be quite useful in his preliminary calculations or for the economist in his comparisons of several process variations. The curves also indicate that the relationship becomes limited in its extension at feed compositions near either one of the products.

Comparison of Empirical Formulae for Fractionating Columns

Since an abundant amount of data was available from these calculations, two well known correlations for obtaining theoretical plates at various reflux values were examined. Gilliland's logarithmic plot,[7]

TABLE 5

Separation 4

Gilliland Logarithmic and Brown and Martin Correlations

α=1.75 D=0.90A W=0.10A

N_m=6.86

FEED COMP.	L/D	N	PERCENT DEVIATION			
			Gilliland		Brown and Martin	
			+	—	+	—
0.80A	0.33	∞				
	0.42	13.6		21.8	3.0	
	0.47	12.3		21.7	3.4	
	0.53	11.6		19.4	5.5	
	0.60	11.1		18.4	6.7	
	0.67	10.6		17.8	7.1	
	0.80	10.1		15.1	8.6	
0.60A	1.42	∞				
	1.78	15.4	6.9		16.7	
	1.99	13.6	4.6		14.3	
	2.27	12.2	2.5		10.9	
	2.56	11.2	0.9		7.7	
	2.84	10.6	1.0		7.1	
	3.41	9.8	0.0		5.4	
0.40A	2.61	∞				
	3.26	15.9	13.6		20.5	
	3.65	13.5	8.0		13.4	
	4.18	12.3	8.9		11.8	
	4.70	11.4	7.6		9.6	
	5.22	10.7	7.0		8.1	
	6.26	9.8	5.4		5.4	
0.20A	5.70	∞				
	7.12	13.7	2.2		3.8	
	7.98	12.0	0.8		0.8	
	9.12	10.8		0.9		1.8
	10.3	10.1		0.0		2.9
	11.4	9.6		1.0		3.0
	13.7	9.0		1.1		3.2

TABLE 6

Separation 5

Gilliland Logarithmic and Brown and Martin Correlations

α=1.50 D=0.90A W=0.10A

N_m=9.83

FEED COMP.	L/D	N	PERCENT DEVIATION			
			Gilliland		Brown and Martin	
			+	—	+	—
0.80A	0.75	∞				
	0.94	17.5		19.0		7.4
	1.05	16.2		18.2		5.3
	1.20	15.1		16.1		3.8
	1.35	14.3		14.9		3.4
	1.50	13.9		12.6		2.1
	1.80	13.4		9.5		0.0
0.60A	2.25	∞				
	2.81	21.0	6.1		11.1	
	3.15	18.2	2.8		6.4	
	3.60	16.4	1.9		4.5	
	4.05	15.3	2.7		3.4	
	4.50	14.5	1.4		2.1	
	5.40	13.4	0.0		0.0	
0.40A	4.00	∞				
	5.00	21.0	10.0		11.1	
	5.60	18.5	8.2		8.2	
	6.40	16.7	7.7		6.4	
	7.20	15.4	5.5		4.1	
	8.00	14.6	5.0		2.8	
	9.60	13.6	3.8		1.5	
0.20A	8.62	∞				
	10.8	18.1		3.2		4.2
	12.1	16.6		0.6		2.9
	13.8	15.2		0.0		3.2
	15.5	14.2		0.0		4.0
	17.2	13.4		0.7		5.6
	20.7	12.2		4.7		9.0

TABLE 7

Separation 6

Gilliland Logarithmic Correlation

α=1.25 D=0.95A W=0.05A

N_m=25.4

FEED COMP.	L/D	N	PERCENT DEVIATION +	PERCENT DEVIATION —
0.80A	3.94	∞		
	4.93	42.9		10.4
	5.52	40.6		5.8
	6.30	38.2		3.0
	7.09	36.3		1.9
	7.88	34.8		1.4
	9.46	32.3		3.0
0.60A	6.42	∞		
	8.02	51.1	7.8	
	8.99	45.0	6.4	
	10.3	40.4	4.4	
	11.6	37.6	3.6	
	12.8	35.9	3.2	
	15.4	33.8	2.7	
0.40A	10.5	∞		
	13.1	48.5	4.1	
	14.8	43.9	5.3	
	16.9	40.2	5.2	
	19.0	38.0	5.8	
	21.1	36.1	4.9	
	25.3	33.5	3.1	
0.20A	22.8	∞		
	28.4	42.6		7.8
	31.9	38.9		6.0
	36.4	35.8		5.3
	41.0	34.2		3.9
	45.5	32.9		3.8
	54.6	30.9		4.3

Figure 9, was investigated and, based on 131 determinations, an average deviation of —1.1 percent was found. The deviations were calculated by the formula,

$$\frac{N-Nc}{Nc} \times 100 = \text{percent deviation}$$

A negative deviation indicates that the calculated plates were slightly less than the value obtained from the curve. This would be conservative when solving for the number of plates at a designated reflux ratio. The reverse calculation would give a reflux slightly less than required. The maximum positive and negative deviations were 18.7 and 21.8 percent, respectively.

The Brown and Martin correlation[1] (Figure 10)

TABLE 8

Separation 6

Brown and Martin Correlation

α=1.25 D=0.95A W=0.05A

N_m=25.4

FEED COMP.	J/J min	N	PERCENT DEVIATION +	PERCENT DEVIATION —
0.80A	0.81	43.2		12.0
	0.72	41.0		7.9
	0.63	38.5		5.2
	0.55	36.5		4.4
	0.50	35.0		4.4
	0.41	32.5		5.5
0.60A	0.78	51.1	6.9	
	0.69	45 0	4.2	
	0.60	40.4	2.0	
	0.53	37.6	0.0	
	0.47	35.9	0.0	
	0.39	33.8		0.3
0.40A	0.78	48.5	2.5	
	0.68	43.9	2.8	
	0.59	40.2	2.3	
	0.52	38.0	2.4	
	0.46	36.1	1.4	
	0.38	33.5	0.0	
0.20A	0.76	42.6		7.8
	0.66	38.9		7.2
	0.57	35.8		7.3
	0.50	34.1		6.8
	0.44	32.9		6.0
	0.36	30.9		6.4

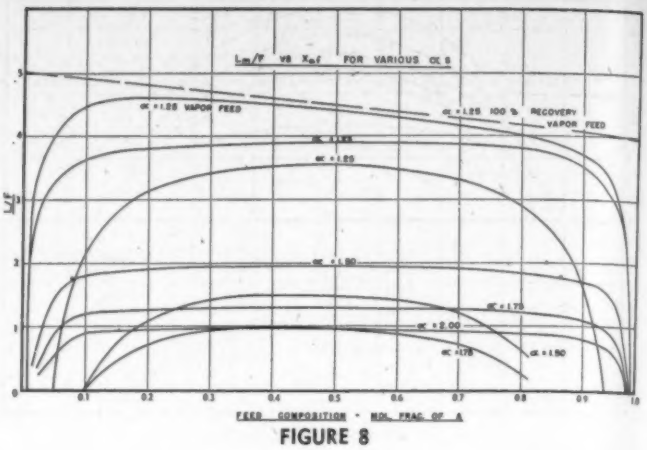
Lm/F vs Xmf FOR VARIOUS α s
α = 1.25 VAPOR FEED
α = 1.25 100 % RECOVERY VAPOR FEED
α = 1.50
α = 1.25
α = 1.90
α = 1.75
α = 2.00
α = 1.75
α = 1.50
FEED COMPOSITION - MOL. FRAC. OF A

FIGURE 8

was next investigated. Brown and Martin plotted J/Jmin versus N/Nm, where J/Jmin represented

$$\frac{\frac{\overline{LV}}{\overline{VL}} - 1}{\left(\frac{\overline{LV}}{\overline{VL}} - 1\right)_{min}} = \frac{J}{Jmin}$$

This can be reduced to Lmin/L for saturated liquid feed and therefore makes their correlation less cumbersome to use (Appendix I). An average deviation of —0.9 percent was found for this correlation. The maximum positive and negative deviations were 20.5 and 14.2 percent, respectively. The correlation of Brown and Martin was based on saturated liquid feed but a suggestion was given by them for correcting their curves for other feed conditions by assuming a feed composition corresponding to the intersection of the operating lines. J/Jmin or its equivalent Vmin/V for separation 6 was found to correlate reasonably well with their curve without making the assumption of a pseudo feed composition. The average deviation was —2.4 percent. The saturated vapor feed case was included in the test of the Gilliland correlation. The maximum positive and negative deviations of each correlation did not occur with the same separation as an inspection of the tables will show. Both of these correlations are probably well within the accuracy required for preliminary design work. In seeking a better representation of the data, it

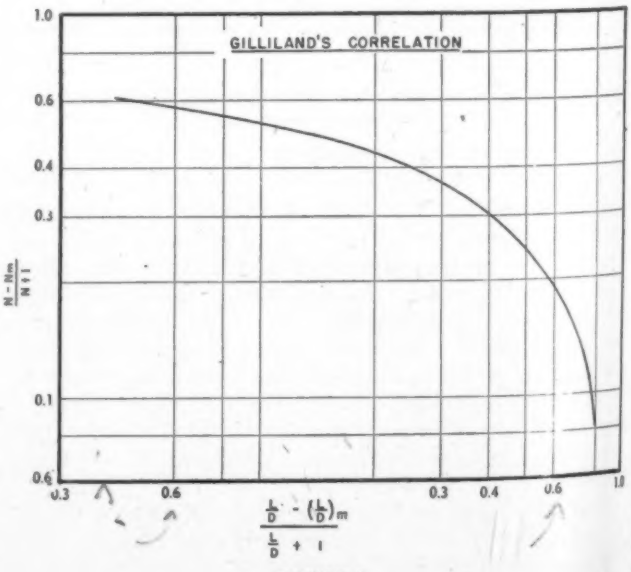

FIGURE 9

would probably be necessary to obtain separate plots for the rectifying and stripping plates. For cases of non-ideal solutions, investigation by a different method is required.

Conclusions

As a rule of thumb for the designer, the function L/F is a constant for the same separation at the same number of plates, regardless of the feed composition. The ratio is not a concrete value but does seem to offer some use. The maximum Lmin/F would be $1/\alpha - 1$ for saturated liquid feed while $(1/\alpha - 1) + Xbf)$ represents the maximum ratio for minimum reflux with a saturated vapor feed. These values represent maximums, the deviation from which becomes greater the "sloppier" the separation, or in other words the less pure the distillate and bottoms. For other feed conditions, the Lmin/F ratio would be less than $1/\alpha - 1$ for subcooled liquid feeds, between $1/\alpha - 1$ and $((1/\alpha - 1) + Xbf)$ for partially vaporized feeds, and greater than $((1/\alpha - 1) + Xbf)$ for superheated vapor feeds. For multiple component distillation these maximums would also hold for the case of adjacent key components if the components heavier than the heavy key are included in the percentage of the heavy key component in the feed. For the case of an intermediate component, these values would not necessarily represent maximums. The data obtained from graphical tray to tray calculations were found to correlate satisfactorily for the Gilliland logarithmic and the Brown and Martin correlations.

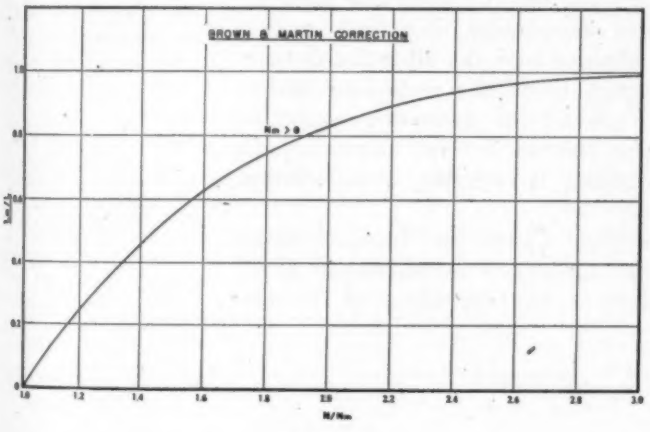

FIGURE 10

In this paper, optimum feed plate location was assumed in all cases. In plant operations it is not always easy to change the feed location to the optimum plate and therefore calculations should be made correcting for this condition when seeking correlations of the above type. Since the adjustments required in multiple component distillation would be very tedious, no such calculations have been included in this paper.

APPENDIX I
Brown and Martin Factors

$$\frac{\frac{\overline{LV}}{\overline{VL}} - 1}{\left(\frac{\overline{LV}}{\overline{VL}} - 1\right)_{min}} = \frac{J}{J_{min}}$$

For saturated liquid feed $V = \overline{V}$ and $\overline{L} = L + F$

$$\therefore \frac{\frac{\overline{L}}{L} - 1}{\left(\frac{\overline{L}}{L} - 1\right)_{min}} = \frac{\frac{\overline{L} - L}{L}}{\left(\frac{\overline{L} - L}{L}\right)_{min}} = \frac{\frac{L + F - L}{L}}{\frac{L_{min} + F - L_{min}}{L_{min}}}$$

$$\frac{\frac{F}{L}}{\frac{F}{L_{min}}} = \frac{L_{min}}{L} = \frac{J}{J_{min}}$$

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The Functions and Responsibilities of a Plant Instrument Department

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INSTRUMENTS for recording, controlling, and indicating process temperatures, flows, pressures, and other similar variables, are recognized as being equally important as the other equipment employed in the plant. Development of instruments and their applications is progressing rapidly whereas, the evolution of the instrument department, in general, is lagging badly.

This paper sets forth, clearly and concisely, the functions and responsibilities of the well-organized instrument department in today's modern refinery. The instrument department is charged with the all-inclusive function: "the assurance of maximum accuracy in all the measuring devices under its care, and optimum control from all the automatic regulating mechanisms under its jurisdiction." Also pointed out for discussion, are the three major functions of the department: 1) selection, 2) installation, and 3) maintenance of the instruments.

Presented before the Second Annual Short Course on "Instrumentation for the Process Industries" at the A. & M. College of Texas, August 27-29, this paper will be published in the bulletin on the proceedings of the short course.

EACH term in this title has several definitions, or shades of meaning, some of which are not applicable to this discussion.

By *functions* we mean the duties, trusts and other business belonging to, or required of, a profession. By *responsibilities* we mean all the obligations and liabilities involved in properly discharging those duties, trusts and other business.

One of the responsibilities of a profession is the competent execution of its functions. This means that the profession must assemble all the necessary talents, tools and other requisites for performing its duties. This engenders other responsibilities. For instance, education of personnel is not necessarily a function of an instrument department; but provision of properly educated and trained personnel most certainly is a responsibility of an instrument department. Therefore, under certain conditions, personnel education may become its responsibility. Briefly, functions breed responsibilities; responsibilities result from functions.

Even the term *instrument department* needs some definition; because there are just about as many different kinds of instrument departments as there are different types of plants. Usually the instrument department is a service organization that has evolved, or that just grew, to meet the needs of the particular plant it serves. There are some that consist of only one or two men whose principal duty is the maintenance of one type of instrument. There are others comprising as many as 100 or more men who service, along with conventional measuring and controlling apparatus, practically everything from the automatic operator on the plant gate to the working whistle.

It is necessary to draw a line somewhere between these extremes; so for purposes of discussion, we have constructed a hypothetical semi-modern chemical processing plant where units have been added gradually over the last 15 years. In general, its processes are continuous, but a few batch-type units remain. It employs a little more than 200 operating personnel supervised by a staff of 30 persons, and employs a maintenance crew of about 125 men. Its warehousing, shipping and clerical staffs excluding management total 150 employes. It represents an initial investment of some $15 million, about a third of which has been written off or retired. About 5 percent of this investment—roughly $4000 per operating employe—was expended for measuring and controlling equipment.

The instrument department at this plant consists of 25 men, including the foreman and a department

head who also acts as instrument engineer. About its duties it has some definite, fixed ideas. It insists that measurement and control is its business. It asserts emphatically that it should service not only the final indicating or recording means, but also all the other elements—that is, the primary element and connecting piping—that make up the measuring system. Likewise, it insists on maintaining all the elements of the controlling system including the measuring system, the controller mechanism, connecting tubing or wiring, and the controlled element, be it valve or other. It wants jurisdiction over all the measuring and controlling devices in the plant with the possible exception of a few pieces of specialized laboratory apparatus. It wants nothing more; it wants nothing less.

Jurisdiction Determined

It does not want to maintain the telephone system, despite the fact that phones are sometimes called "instruments." Neither does it want to service the several loud-speaker and public-address systems in use in the plant. It has won a jurisdictional dispute with the machinists and was awarded servicing control valves. It has lost a jurisdictional dispute over instrument piping to the pipefitters, and a similar one over pyrometer leadwire to the electricians, with the express provision that the instrument department has the authority to condemn work not meeting its standards. It does not want, but is saddled with, a large number of "nuisance items" passed on to it simply because no other department could, or would, service them properly. This apparatus includes such items as vacuum eductors and ejectors, refrigerators and water coolers, steam-jet hot water heaters, etc. It has under its care the various items manufactured by approximately 40 firms. It is struggling along with an educational program, some nebulous policies, and mediocre cooperation.

Thus we have our instrument department. We think it is fairly typical. Its prototype, complete with organization, jurisdiction, attitudes and problems, exists in several plants with which we are familiar.

What are its functions? What responsibilities do they entail?

Function Established

In general, as we stated in the definition, a function of the instrument department is some duty that is expected of it. This implies that functions are determined or established by some agency outside of the department. Often they accumulate by some other agency saying "Let's turn this over to the instrument department." This usually occurs where the instrument department just grows, and duties and assignments keep accumulating in a sort of "hodgepodge" that eventually must be straightened out. Occasionally, recognition comes directly from management along with a clear-cut definition of duty, but this is rather rare. Usually, it is up to the head of the instrument department to force the issue. Quite often he voluntarily defines his functions in establishing the character of his responsibilities.

Regardless of past attitudes, methods of growth, when or how determined, it is usually established that the instrument department has one all-inclusive function: "the assurance of maximum accuracy in all the measuring devices under its care, and optimum control from all the automatic regulating mechanisms under its jurisdiction." This is the father of all its other functions and the origin of most of its responsibilities. Three major functions are its direct descendents; they are: 1) the selection of the instrument, 2) the installation of the instrument, and 3) the maintenance of the instrument.

Accuracy of measurement and optimum control are dependent on these three things, no one of which is any more important than the other. Selection, installation, and maintenance, must be given proper attention if the primary function is to be discharged. Since the instrument department is responsible for accuracy and control quality, these three functions and all their attendant responsibilities should be placed in its hands.

Let us briefly examine some of the responsibilities these functions carry with them. The first thing to be determined in the selection of the instrument is its application. This requires a basic understanding of the process. The person making the selection must understand the duties required of the instrument so that he can determine its range, as well as its accuracy and sensitivity specifications. He must know characteristics of the material with which it is to be used so that he may choose the proper materials and construction details. He must know its physical location so that he can select proper case design, explosion-resistant characteristics, etc. He must have some knowledge of operating details and be able to recognize job peculiarities that, particularly in automatic control service, influence efficiency. He must know the characteristics of pumps, heat exchangers, columns, blowers and other equipment with which his mechanisms are to be used.

This constitutes a large order. It is tantamount to saying that each instrument department must incorporate a process-control engineer, but that is not necessarily true. If proper cooperative policies are worked out, this function can be discharged rather easily and with very good results. This will be discussed in more detail later. Suffice to say for the present that the instrument department must have available all the knowledge and talents set forth above. It can then proceed with its other duties in making a proper selection; i.e., the type and grade of the instrument for a given application.

The choice of details such as the physical principle upon which measurement is based, design of primary element, principle and method of intelligence-transmission, etc., should be surrendered completely to the instrument department. They are just as much a part of the measuring system as the final measuring means. And most certainly the instrument department should specify the grade of the instrument; that is, the refinements, the number and character of its control functions, if it is a controller. Likewise, if it is a controller, the instrument department should select the principle to be utilized in control, be it electrical, pneumatic or other; and should calculate the dimensions and specify details of the final controlled element and all its appurtenances.

Ultimate Cost Is the Thing

This, too, sounds like a large order; but as the head of any instrument department knows, it is not at all difficult if the proper fact-finding organization has been set up within the department. This involves other responsibilities, of course. A complete cost and performance-data file must be set up to guide selection aright in the matter of costs. Incidentally, we

might make the observation here that first cost is relatively unimportant in the selection of an instrument. Ultimate costs are what count. If a higher-priced instrument requires less maintenance, will make more product, or better product, it is much less expensive in the end than a low-priced one. Experience, the instrument man's chief stock in trade, is essential in proper selection of instruments; but an ultimate cost file is very helpful if an argument arises with other departments over initial costs. It may be beneficial for the instrument department to set up and adhere to a standardization policy. This reduces parts stock among its many other beneficial features, and it has a direct bearing on instrument selection.

The importance of proper instrument selection cannot be over-emphasized. If all the details that constitute a measuring and/or controlling system are not thoroughly investigated and provided for, the successful functioning of the instrument will be a matter of luck, and these important details are so numerous that the odds are 10 to 1, 50 to 1, or 100 to 1 against optimum operation. Doubtless all of us have seen head meters applied on the discharge of simplex reciprocating pumps and accurate measurements expected. Many of us have seen two-position pressure controllers applied to fractionating columns whose temperatures must be held in steady state. These two practices are for the most part ancient history now. Everybody knows better. Let's take something more modern.

In cascaded control systems, we quite often encounter a liquid-level controller whose air-output pneumatically sets the index on a rate-of-flow controller. As often as not, probably more often than not one will find the liquid-level controller equipped only with proportional band adjustments, while the flow controller is equipped with very elaborate mechanism for proportional speed floating action. This is exactly the opposite of what is required for optimum control. The level controller, the master in command of the process, whose response is influenced by inflow as well as outflow, by vessel shape and other factors, cries out in a loud voice for floating action (or "automatic reset" to use a condemned, but probably more widely recognized term). Its slave, the flow controller, with practically zero dead time and a very short time constant, has only one duty—to obey the commands of the LLC. It needs only proportional position action and will probably respond best when set only slightly under ultimate sensitivity.

Selection of Instrument

Only the instrument man knows these things. The process man can't keep the tremendous volume of such details in his head. Instrument selection is the right, the duty, and should be a recognized function of the instrument department. It carries with it one other important responsibility—keeping up with the latest developments, but this will be discussed in more detail later.

Let us now examine the second of the major functions, that very important item, installation. Regardless of the quality, type, grade or initial cost of the instrument, it can never function properly unless it is properly installed. We have seen some instruments that would render a far greater service were they completely removed and stored in a warehouse. Due to faulty installation they are purveyors of false information, more detrimental to the operator than no information. An instrument improperly installed is seldom accurate, always expensive to maintain, and is a general source of annoyance to everybody concerned. Further, its untrustworthiness affects the morale of the operator on the theory "if you can't trust it, why worry about it?"

It is a paying proposition to correct faulty installations, but it is much more economical to prevent them. This can be done by placing supervision of all installation, whether local or by contractor, in the hands of the instrument department. We are in complete agreement with our typical instrument department. It should either do the work itself or have authority to condemn the work of others.

If the instrument department is assigned this duty, it must shoulder several responsibilities. In the first place, it must carefully compile a complete set of installation standards to be presented to the people doing the work. It must check the contractors typical installation drawings to see that they conform to these standards. When piping, wiring and equipment prints are available, it must carefully check them for such items as improper length of orifice runs, faulty electrical hookups, improper location of pyrometer wells, etc. In short, it must do everything to correct faults before they emerge from the blueprint stage.

Instrument Inspector Suggested

But not all the faults can be corrected in this stage. The contractor is handicapped when it comes to instrument installation. He must use whatever labor is available locally for his installation crews, and it is seldom that he can find on the labor market anyone who understands even the rudimentary principles of instrumentation. As a result one may find a Series 60 weld-neck orifice flange welded to a Schedule 40 meter run without regard to the resulting "collar" that distorts the stream flow. "Double-reverses" are found in pyrometer circuits, pressure seal pots are found mounted up-side-down, temperature recorder sockets are mounted in dead areas instead of the point of highest velocity. These things are really not the fault of the contractor and quite often are embarrassing to him when they are pointed out. We believe he will usually welcome, what it is the duty of the instrument department to provide, a competent instrument inspector. This man should have a complete knowledge of instrumentation, and should inquire of workmen before they do a job how they plan to do it and thus prevent their doing it wrong. This is better than eventual condemnation. A competent man using this method should be able to save considerable sums because correction of faulty installation is expensive. A recently published figure for one company showed approximately 5000 man-hours for correcting faults, breakage, etc., on one large plant. Doubtless this figure is small compared with losses that would have accrued had not the faults been corrected.

Now let us turn to the best known and probably most widely recognized function, maintenance. So many are the responsibilities that they are difficult even to enumerate. However, they are comparatively well-known and prolonged discussion is not justified. A brief classification should be sufficient.

In general, this function can be divided into four important duties. The first is provision of *proper departmental personnel.* The attendant responsibilities are compilation of adaptability tests and "entrance examinations;" education and training of mechanics;

provision of suitable texts and maintenance instructions; establishment of satisfactory working conditions; and maintenance of departmental morale.

The second is the provision of *suitable shop facilities,* and the responsibilities are: provision of adequate space to work equipped with the best obtainable lighting and ventilating facilities (air conditioning where required); procurement of all necessary cleaning equipment, tools and labor saving devices; procurement of adequate primary standards, calibrating and testing equipment; and provision of suitable and convenient space for the storage of tools, parts, and equipment in process of, or awaiting, repairs.

The third is *departmental management* entailing such responsibilities as distribution of personnel; dispatching the work; maintenance of safety; management of supplies; compilation of cost and data files; preparation of charts of lubricants, packings, diaphragm materials, etc.; compilation of a suitable library, and the many other details that constitute the efficient handling of the departments.

The fourth, and one of the most important, is *departmental cooperation.* It necessitates establishment of and adherence to definite uniform policies with the other departments in the plant. Periodic meetings with the heads of these departments along with representatives from the technical section, the laboratories and management often prove quite fruitful. It is only at such meetings that instrument exchange policies, spare stock agreements, and uniform procedures can be worked out. There are other benefits to be derived from such gatherings to be discussed later.

These, we think, are the most important recognized functions and responsibilities of our typical instrument department. As stated before, they have been known, talked about and written about for years. This does not mean, however, that they have been accepted universally. In some plants the instrument department has no part whatever in selection, and very little part in installation. In others it is denied the right to service control valves. In still others, despite the fact that the instrument department is charged with accuracy of measurement, heads of other departments indiscriminately change the elevation of thermal systems, and calculate and install new orifice plates without its knowledge.

Management's Role

Unhappy, indeed, must be the supervisor of such a department, and uneasy must lie his head. His first, most imperative responsibility is to rectify these conditions. Despite the fact that his efforts may precipitate jurisdictional disputes and minor interdepartmental rows, we doubt that he will have much difficulty, if he carries his argument to top management. Management knows that, if an instrument department is allowed to service only the mechanism in the instrument with all pipe work done exclusively by the pipefitters and all control valves maintained by the machinists, then the instrument department cannot be held responsible for control quality. It realizes that the agency actually responsible is the one to whom the heads of these three groups report. Management will doubtless endorse the instrument department's recommendations, and grant the authority necessary to rectify such conditions.

Such rectification may prove embarrassing, however, because despite the fact that it may be due to haphazard growth, in most departments this situation should have been cleared up years ago. Rectification now is based on "hindsight" rather than "foresight." Nevertheless, it should be done. Selection, installation, and maintenance are all functions of the instrument department, and as our typical instrument department contends, complete authority over all measuring and controlling system elements should be granted to it. Otherwise, it cannot competently discharge its primary function.

We have said that corrections based on "hindsight" can be embarrassing. This emphasizes the importance of another type of responsibilities—those based on "foresight." These duties have their origin in a rather broad, blanketing function, never quite definite, sometimes not even recognized. Management, in most cases, expects its instrument department to "stay on its toes," to keep informed on latest developments, to project its thinking into the future, and organize its resources to meet future requirements. Be it nebulous and hazy, this is a function of considerable consequence; and of all its attendant responsibilities, there is one so imperative we are inclined to issue it as a command, "stay young!"

"Stay Young!"

A few heads of instrument departments have been in the game for 10, 15 and 20 years and some of us are getting a little gray and others are growing bald. But, regardless of the condition outside the skull, what's in it must be amenable to new ideas, even if they are definitely of "long-hair" derivation. We may be getting a little heavy around the waist-line, but we can tolerate no middle-aged fat between the ears. We are in the youngest, fastest-moving profession in existence. We must keep our thinking young, our attitudes aggressive, and our horizons wide. As individuals, we can do this by participating in programs like this one, by membership in technical societies, by serving on the committees that are gathering together some of the loose ends that were scattered helter-skelter by the rapid progress of our profession. Departmentally we can "stay young" by hiring in young graduates who have exerted the extra effort to master courses in special measurements, process control, and servo-mechanisms which, incidentally, are seldom required for graduation. These youngsters may be labeled "long-haired boys," but usually they are well-grounded in the arts of physical analysis and mathematical solution. Their ability, exuberance and aggressiveness, under the reins of experience, should prove highly beneficial to our departments.

The second responsibility is to analyze trends. "Trends" here do not refer to, let us say, the tendency to use rectangular-case instruments instead of round-case types. The trends we speak of refer to the significant movements of and improvements in measurement and control methods, and their influence on process design and operation. Analyzing them amounts to extrapolating the instrumentation progress curve, and before we can extrapolate we must examine the existing portion of our curve and determine the character of the practices of bygone years.

In any industry you choose to examine, process design and instrumentation have advanced together. Their progress has been not unlike that of two boys tied together for a three-legged race. Each takes an individual step, then they take a step together. That is exactly what has happened in the case of processes and instruments. A process would demand a certain instrument and somebody would build it. The builder

would get a new idea, build a model and take it to the process designer, who might be able to use it to better his process. Their progress was somewhat jerky, and there were some spills, but they went places. Indeed, they are continuing to go places for, in general, this three-legged race is still going on. These two agencies have hobbled and hopped through three "instrumentation eras" and are now entering the fourth.

In the beginning of any industry, processes were crude. A minimum of basic equipment was used and operators were instructed to do things a certain way so the resulting product would meet specifications. A few pressure gauges and mercury-in-glass thermometers were used, and operators found by maintaining certain conditions with them, better product or higher yields could be obtained. This was, let us say, *the pressure-gauge era.*

Process design was making headway but chiefly in better equipment design. A new type pump was hailed as an innovation, but operation still depended on doing certain things a certain way, or maintaining those "certain conditions." Operators began to suspect their subordinates were not maintaining those conditions and installed recorders as tattle-tales. This was a new era in instrumentation that may be called the *recorder era.*

Thermodynamics Applied

Although they continued to demand bigger and better machinery and vessels, process designers also began to apply thermodynamics and other fundamental laws of physics and chemistry to their reactions. And they found that, for optimum yield of highest quality product from a given raw material, these "standard conditions" must be maintained exactly and continuously. This is something that human beings cannot do for long without going raving mad; and so the *controller era* was born. Controllers were crude at first, quite erratic, and somewhat unreliable. It was found necessary to establish special crews to service them along with the indicators and recorders of earlier years. Thus, instrument departments were born.

Under careful nursing and pampering by instrument men, coupled with improved design, these devices were coaxed into maintaining those all-important "standard conditions." However, process men and operators found that these standard conditions were not enough for continuous optimum high-quality yield. They were adequate for a given raw material, but unfortunately, in continuous processes particularly, changes in composition of feed stocks and reacting chemicals made the "standard conditions" less suitable. As a result laboratories were enlarged, and special sections were set apart for control (that word should be significant). Samples were taken periodically at designated points in the process stream and dispatched to the laboratory for analysis of properties. From these analyses the "standard conditions" were altered to meet new requirements. In short, despite the fact that the reaction environment is being held in steady state by condition-regarding devices, the process is actually being controlled by property-analysis in the laboratory.

Please note that we have changed the tense of our verbs. We are in the present now. But to continue, this system violates one of the cardinal principles of instrument men, "keep controller dead-time to a minimum." We are accustomed to dead-time measured in seconds and minutes, whereas dead-time in this control system is a matter of several hours. Realizing the amount of product that can be slopped in this interval, foresighted process engineers are already demanding properties-measuring instruments for continuous service on process streams. Already some progress has been made in this direction. Devices for measurement, and sometimes control, of vapor-pressure, density, viscosity and color are already in service. pH, automatic titrimeters, refractive index indicators, end-point and initial-boiling point devices are already available. We are now entering the *analyzer era.*

The Analyzer Era

As we enter this new age, we find that process engineers are still improving their machinery and other allied equipment, but not as fast perhaps as instrument manufacturers are developing their conditions-measuring instruments. Temperature instruments having a total span of 20° F. at elevated temperatures are now available; suppressed range pressure instruments with 15 psi spans and compensated for atmospheric pressure can be obtained; liquid level controllers that visibly respond to the addition or withdrawal of a few drops of fluid are on the market; and in flow measurement, head meters are being developed with an accuracy approaching that of volumeters for some services. Pneumatic control mechanisms have been vastly improved, and mathematical methods for determining optimum controller settings have been worked out. Although such improvements will doubtless continue, most engineers agree that perfection of conditions-regulating instrumentation is not the final answer. Properties-measuring devices for purity and quality must be incorporated directly in the process.

Laboratory Is Cradle of Instrumentation

The womb of development is fertile with ideas for these devices, but not all are in the gestation stage. Many of them are already born and are kicking around in that "cradle of instrumentation," the laboratory. It behooves the instrument department to look carefully at them to see what added responsibilities they will bring with them. Quite a few of them will be based on the electromagnetic spectrum; spectroscopes and spectrometers utilizing the many frequency bands that lie between the already explored limits, UHF radio waves at the low-frequency end, and X-rays at the high-frequency end. Already infra-red, ultra-violet and the visible bands are doing yeoman service in the laboratories. Refractive index, optical rotation and optical disperson are other methods based on this phenomenon that will soon be used for process service. Other types will be based on a variety of potential measurements such as ionizing potential, ion concentration and the various kinds of polarographs. Both electrical and thermal conductivity will be used, along with ultrasonic vibration and possibly variations of the mass spectrometer. Automatic titrimeters will increase in usage.

These devices will be built as simple and rugged as possible, but regardless of all efforts toward simplification, such mechanisms will certainly be much more complex and involved than our relatively simple conditions-measuring instruments of today. A thorough knowledge of physics and higher mathematics will be required in repair and calibration. One re-

sponsibility immediately revealed by this extrapolation is that of providing suitable personnel for properly servicing such equipment. In general, we feel that this task is too great for the average instrument repairman of today. It will call for much higher intellectual ability and technical skill, probably necessitating an entirely new classification in our Instrument Department. These people would probably be classed as technicians rather than repairmen.

Another Progressive Step

After having battled with employe groups, labor unions and even in some cases the lower levels of management, over educational qualifications, adaptability tests, advancement programs, etc., the instrument man is tempted to throw up his hands at this suggestion. A glance at the record, however, will reveal that he has always faced the problem of keeping his personnel "educated up" to the level required by the latest devices. The technological level of instrument personnel has been climbing all the time. The suggested additional personnel is merely another step up the ladder of progress. Regardless of all opposition, a means must be found to provide men suitably trained for the intelligent selection, proper installation and adequate maintenance of these devices of the future.

It is the responsibility of the instrument department to establish some method of keeping this personnel in touch with these developments so that selection can be based on sound judgment, if nothing more. It is obviously its responsibility to supply such personnel for supervising the installation of such equipment. If the contractor is unable to find labor capable of installing conventional instruments, certainly his men will be unable to correctly install these special mechanisms. Furthermore, it is the duty of the instrument department to extrapolate its requirements curves for maintenance facilities and begin negotiating for the necessary shop space, air-conditioned rooms, primary standards, special tools and other items for the proper repair and calibration of such equipment. From experience we would advise that, particularly in studies of shop space and air-conditioning, it looks at least five, ten if possible, years in the future.

Responsibility AND Authority

We have said earlier that responsibility must be accompanied by authority, and doubtless the question of "where do we get the authority" has already arisen. We think anyone will have very little trouble if he takes his problem directly to management. There has been a tremendous change in the attitude of management toward measurement and control in the last few years. This applies particularly to top management. In the lower brackets, probably because they are "so close to the forest they can't see the trees," certain individuals are likely to be lackadaisical or even antagonistic towards instrumentation. In the upper strata, however, enthusiasm runs high.

This is probably due to its dollar-and-cents value demonstrated during the war years, for management realizes as we do, that our processing plants manned with hastily trained and inexperienced personnel would have been much less efficient had it not been for the measuring and automatic regulating equipment that kept them on them on the line in steady state. Furthermore, management's attention is being called to instrumentation regularly. Such publications as *Business Week, Fortune,* the staid *Wall Street Journal,* and a host of others, now devote space to measurement and automatic control and the benefits to be derived therefrom.

Called to Joint Meetings

This attitude of top management is being reflected in industry generally. We know of several large companies that periodically call in their instrument engineers to joint committee meetings for discussion of mutual problems and latest developments, and for the dissemination of information of general interest. We know of one company in which this movement has been extended even further. Each instrument engineer on this committee has been encouraged to organize within his own particular plant, or division, a field group or sub-committee whose duties are somewhat similar to, but possibly more complex than, those of the parent committee. Organization of such a committee in a typical plant consists of representatives from management, the laboratories, the process design section, each operating department, instrument maintenance and instrument engineering sections. The group is normally headed up by the chief instrument engineer and meetings are held monthly. All information passed out from the parent committee is distributed to the ultimate user by these group meetings. In like manner, troublesome problems calling for new or improved equipment are collected through these channels and passed on to the parent committee. These are definite advantages over past methods, but they are only a fraction of the advantages to be realized from such a group.

Controllability Important Factor

Let us look at its possibilities in process design. As we stated earlier, our typical plant with its limited investment can ill afford to pay the salary of a first-class process-control engineer. Yet it must have available all the talents usually concentrated in such an individual, because process design in its normal course of progress is also entering the new era, the *analyzer era.* No longer is the plant laid out, equipment selected, and details completed before the flow sheets are turned over to the instrument department for "tacking on" its instruments. In most industries, at least some consideration is given to control requirements and instrumentation in original plant design.

Although this practice is not yet carried out to the degree that it should be, we are confident it will be in the future, because the idea is based on sound, logical reasoning. We build our plants to attain certain ends. To attain those ends the processes must be controlled, preferably automatically, since optimum yield and highest purity can thus be obtained. Controllability, then, is one of the primary considerations, and we predict that control requirements will play an increasingly important part in the construction and arrangement of all process equipment in the future. It is already realized that instruments are now being used to overcome faults that could possibly be eliminated by alterations to fundamental design and arrangement of equipment, and some corrective steps have already been taken. For instance, we no longer find a reciprocating pump supplied where the flow from it must be accurately measured. Likewise, most vessels are now arranged so that greatest benefit will

result from liquid level controllers. Attention to such details will increase.

Mode of Control First

In our opinion, in design of future plants, the mode of control will probably be considered first. Suitable instruments for establishing and maintaining this mode will be selected, and allied equipment will be chosen that, after incorporation of all other requirements, will best meet the needs of these instruments. Instrumentation will come into its deserved place in the *analyzer era*, and so will the process-control engineer. Although we do not have this individual in our typical plant as yet, in such a committee as that just described, we have all his knowledge. The only difference is that it is in three heads instead of one, but that is overcome by bringing the three heads, the process engineer, the operator and the instrument engineer, together in committee meetings.

Evaluate New Devices

Proper selection of instruments, we have said, depends not just on knowing about latest developments. To prevent buying a "pig in a poke," new devices should be tried out, evaluated. This is one of the functions of this organization. Each field group does a certain amount of test work each year with moneys assigned for that purpose; and its reports are circulated to all other participants in both the parent committee and field groups.

The interests of this organization embrace every phase of measurement and automatic control. It compiles standards, distributes educational texts and films, performs many services other than disseminating information and solving specific problems. Perhaps the greatest justification for its existence is the link this organization forms between the process designer and the instrument manufacturer. Earlier we compared the relationship of these agencies to participants in a three-legged race. We have seen such races in which a pair achieved remarkable speed. Their secret was coordination, and this committee constitutes coordination between these two agencies.

Motivated by High Ideals

The primary consideration in setting up this organization, was of course, profit. Logically one might expect it to be a closed circuit, a rather secret group whose findings are regarded as strictly confidential. But such is not the case. Emanating as it does from top management, this movement is apparently motivated by the highest of ideals. This committee has been instructed to work openly and freely with anyone interested. No secrets are withheld. Its reports are, of course, restricted to circulation within the company, and there are a few items involving patent rights that must be regarded as confidential until sufficient coverage is obtained. But the bulk of its findings are available to industry simply for the asking.

There is evidence of other high ideals, too; some that instrument departments in general would do well to emulate. Speaking before this committee, the president of this particular company laid heavy emphasis on the fact that this committee's activities should never be directed toward throwing men out of work. Its function is to increase man's productivity, to make more goods for more people at less cost and with less physical labor. This, we think, exactly expresses the feelings of all instrument men, but the idea can well use more publicity.

Benevolent Attitude Suggested

A little thinking should convince even the most illiterate person that the progress of mankind since the dawn of civilization has been dependent on technological advancement. Yet, we find a relatively large number of our people, some of them comparatively well-educated, who oppose every innovation in applied science on the theory that it throws people out of work. Such people constitute a menace to our profession, and their theories can best be opposed by common-sense counter-propaganda. It is the duty of every instrument man to let the public know that he does not intend to deprive anybody of his job. Actually, the instrument man's attitude toward society should be benevolent. His aim should be a social order in which no one ever has to work very hard. The instrument man has a particular obligation in this regard. He has in his hands ways of amplifying feeble forces to shift great weights; means for effortless solution of complex mathematical problems; methods for controlled distribution of great quantities of energy. And yet, we find that, of the millions of horsepower utilized each day, a large portion is controlled by back-breaking manual methods. Truly, the instrument man's horizons are infinite.

It is his responsibility to keep his standard high, his march militant.

Applications of Thermodynamics to Hydrocarbon Processing

Part III

ENERGY AND ENTROPY FUNCTIONS

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THE concepts of conservation and degradation of energy together form the foundation for the development of the thermodynamic equations and charts required in making phase equilibria, work and heat balance calculations for hydrocarbons in petroleum processing. Conservation of energy, which is expressed by the first law of thermodynamics, was treated in Part II. By means of the first law, various relations were formulated, but the development of these equations could not be carried to completion because of the limitation of the first law. The second law of thermodynamics, which deals with the degradation of energy and introduces the concept of entropy, will now be presented and the equations developed for various thermodynamics potentials.

THE first law of thermodynamics relates to conversion of energy in one form to another but throws no light on the availability of energy for conversion. This is taken care of by the second law through a property called "entropy." In simple language, the "second law" states that "heat will not of its own accord flow uphill" and entropy is defined as "an index of the unavailability or degradation of energy." Entropy, per se, is very seldom used in applying thermodynamics to hydrocarbon-processing calculations but it enters into the development of practically all of the thermodynamic tools that are used so frequently. The first and second laws of thermodynamics, (i.e. the conservation and degradation of energy) together form the basis for most of the thermodynamics discussed in these articles.

Degradation. According to the second law: Any process, which calls for the transfer of heat from a low temperature level to a high one without the addition of energy from an external source, is impossible. Mechanical refrigerating machines bring about this transfer of heat from a low temperature level to a high one by the addition of work in the form of compression. For absorption refrigeration systems, the required energy is added in the form of heat. In both of these cases, the heat is pushed uphill, in one case by a compressor and in the other by a boiler. Without the addition of extra energy, heat will always go downhill from hot to cold bodies and thus become degraded or less available. This is a phenomenon of nature with which everyone is familiar. If it was not true, perpetual motion would be possible and ships could cross the oceans by engines run on heat taken from the sea only.

Practically all industrial processes involve the conversion of energy from one form to another. In undergoing such a change, the energy becomes less available for useful purposes. Some energy always goes down the "sink," and a small amount is lost through heat losses and friction. The "sink" for a furnace is the stack where flue gases carry low-grade heat to the atmosphere. The barometric condenser is the "sink" for a condensing-turbine; the lower the temperature and pressure maintained by the condenser, the more useful work can be obtained from the heat before it is lost to the "sink" and the higher the turbine efficiency will be. Cooling water is the low-temperature heat "sink" for most hydrocarbon processes. It is more accurate to speak of the degradation of the system as a whole rather than the dissipation or degradation of the energy of that system. In many cases, such as the diffusion of one gas into another, the process does not involve any appreciable energy change.

Energy that goes down the "sink" becomes less available for useful purposes even though most of it may be recovered by heat-economy devices. This unavailability of energy is measured by the entropy. Entropy is usually explained by the Carnot Cycle, which is a standard of perfection. Before proceeding to a more precise statement of the second law and a mathematical definition of entropy, attention will be given to "ideal" or "reversible" and "actual" or "irreversible" processes. This discussion will prepare the way for the Carnot Cycle.

Irreversibility. A series of processes which may be repeated over and over in the same manner and order is said to be a cyclic process or a cycle, of which there are three general types, namely: (1) cycles in which the working fluid stays in the system and undergoes a series of processes of such character that it returns to the same state, for example the condensing steam power plant where the condensate is recharged to the boilers or the absorption of wet gas with a recirculating lean oil; (2) cycles in which the same series of operations are repeated in a cycle with the working fluid being replaced each cycle and consequently, never returning to its original state, for example, an internal-combustion engine where a fresh charge of fuel is taken into the cylinder each cycle, or a hydrocarbon conversion process where the fluids involved are renewed each cycle, and (3) non-flow cycles in which the working fluid undergoes a series of operations while retained wholly within a vessel. Cycles of the first two types are the most common in petroleum technology. Those of the third type

are not employed because it is usually preferable to perform the various operations more advantageously in separate devices specifically designed for the distinctive functions. It is frequently convenient to conceive such hypothetical cycles in studying more practical cycles, however.

Cycles are made up of a series of processes, operations or changes of different types. Heat may be added to or removed from a fluid at constant pressure or temperature. Work may be done by or on a fluid at constant pressure or temperature, with or without adding or removing any heat. For all these changes the working fluid is at a given set of conditions and has a given amount of energy at the start, and after undergoing a change, ends the process in a different condition and with a different amount of energy. In the thermodynamic sense of the word, these processes are not reversible. The criterion for reversibility is that the process may be reversed after completion and the fluid made to return from its final to its initial state with all energy that has been transformed during the process being returned to the original form, amount and location. All actual processes and changes of state are thermodynamically irreversible as there are always some degradation of energy, such as heat and friction losses. The second law of thermodynamics can be interpreted as stating that when an actual process occurs it is impossible to invent a means of restoring every system concerned to its original condition without the expenditure of additional energy.

Although all actual processes occurring in nature are irreversible, an ideal reversible process is nevertheless imaginable and it is frequently desirable to set up hypothetical processes as a standard of efficiency for actual processes. Such an ideal process, which is usually called a reversible process, is one in which all friction, electrical resistance, heat losses by radiation, conduction and convection, or other such sources of dissipation are eliminated. A reversible process is regarded as the limit of actually realizable processes. Stated in another way: A thermodynamic process is reversible if, at any stage, a differential decrease in potentials (temperature, pressure, voltage, etc.) causing the change will result in a reversal of the process itself, both in direction and in all its quantitative effects. The two most common reversible processes are: (1) an adiabatic (no heat added or removed) and isentropic (constant entropy) change; and (2) the isothermal addition or removal of heat.

Entropy

A quantitative measure of the degradation of energy is necessary for the application of thermodynamics to practical problems. The fact that heat at a low temperature level is less available than heat at a high temperature level, suggests the ratio of heat added or removed to absolute temperature as this standard of measure for the degradation or unavailability of energy. This ratio has the same dimensions as heat capacity, i.e. calories or Btu per degree, and is called the "entropy." The entropy of a body or system of bodies may be changed by changing the numerator or denominator of this ratio or both. Adding heat or decreasing the temperature increases the entropy of a system. Degradation of energy is accompanied by an increase in entropy. An increase in the entropy of a system means the energy of that system has become less available for useful work. At this point it is well to point out that complete systems must be considered to get a correct picture of what is going on. For example, the generation of steam at constant pressure involves an increase in the temperature, enthalpy, and entropy of the water. The increase in entropy does not mean that the energy of the steam has become less available. In fact, the increase in temperature is evidence that energy is more available. When the entire systm, including the combustion of fuel under the boiler, is considered, there is a net degradation of energy and an increase in the entropy. The total degradation of energy in two successive processes is equal to the sum of the degradations for each process. For example, in a steam power plant, degradation of energy occurs in the steam generation process and in the power generation process, the total degradation being the sum of these two degradations.

Consider two cases of steam generation in a boiler. In the first case, a highly-superheated high-pressure steam is produced while in the second a low-temperature, low-pressure steam is made. Both of these processes are thermodynamically irreversible. Which is the most irreversible and how may this irreversibility be measured? The difference in temperature between the steam and the flame is less in the first case than in the second, making the process of generating high-temperature steam less irreversible than the process of generating the low temperature steam. The less this difference becomes, the closer the process approaches reversibility, suggesting a scale of irreversibility. It will be expedient to define the extent of irreversibility of thermodynamic processes by Q/θ, where Q is the heat received and θ is some quantity which qualitatively satisfies the definition of temperature. When the function θ is determined, the quantitative definition of the degree of degradation will be complete. By means of thermodynamic equations involving the entropy, it can be proven that θ, which Kelvin called the "thermodynamic temperature," may be completely identified with the absolute temperature scale. Absolute temperature is defined by means of a perfect gas, zero on the absolute temperature scale being the temperature at which the volume of a perfect gas is zero. On the centrigrade scale, this temperature is —273.1°C., and on the Fahrenheit scale it is —459.6°F. In order to avoid duplication and confusion in the following formulae, we will say that $T = \theta$ and use the absolute temperature scale.

The value of the ratio dQ/T will be called the increase in entropy or:

$$S_2 - S_1 = \Delta S = \int dQ/T \qquad (36)$$

In expressing the entropy change during an irreversible process as the difference between the entropy at the end and the entropy at the beginning, it is implied that entropy is a property and therefore that the entropy change depends solely upon the initial and final states. By whatever path the system proceeds from state 1 to state 2, the degradation of energy is the same. As in the case of the energy and the enthalpy, differences rather than absolute values of the entropy will be adequate for practically all problems. Entropy is an "extensive property" so the entropy of a system is equal to the sum of the entropies of its parts.

For an infinitesimal process, equation 36 becomes:

$$dS = \frac{dQ}{T} \qquad (37)$$

This very important equation states that the increase in the entropy of a system, or part of a system, is

equal to the heat which it absorbs divided by the absolute temperature. It is this fundamental equation which Clausius used for his original definition of entropy.

The total entropy change for a reversible process is zero. In such a reversible process it follows that the entropy change in any part of the system must be equal and opposite in sign to the entropy change in all other parts of the system involved. In an irreversible process the total entropy of the system concerned increases. It is important to see clearly the connection between the entropy and the reversible processes.

Entropy Changes. When heat flows between two systems of different temperatures, the process is more nearly reversible the smaller the temperature difference. If a system, with heat capacity C, absorbs heat from a reservoir of infinitesimally higher temperature, and thus rises through the temperature interval dT, so that:

$$dQ = CdT \tag{38}$$

combining with equation 37 gives:

$$dS = C\frac{dT}{T} \tag{39}$$

Since the entropy is a property, the entropy changes of the fluid receiving heat are independent of the temperature from which the heat flows and equation 39 is true for any infinitesimal rise of temperature, no matter how produced.

Ordinarily the heating occurs either at constant volume or at constant pressure and:

$$dS = C_v\frac{dT}{T}\text{; or } \left(\frac{\delta S}{\delta T}\right)_v = \frac{C_v}{T} \tag{40}$$

and

$$dS = C_p\frac{dT}{T}\text{; or } \left(\frac{\delta S}{\delta T}\right)_p = \frac{C_p}{T} \tag{41}$$

Combining equations 16 (Part II) and 40 gives:

$$\left(\frac{\delta S}{\delta T}\right)_v = \frac{C_v}{T} = \frac{1}{T}\left(\frac{\delta E}{\delta T}\right)_v \tag{42}$$

Differentiating with respect to V gives the following relationship:

$$\frac{\delta^2 S}{\delta T \delta V} = \frac{1}{T}\left(\frac{\delta C_v}{\delta V}\right)_T = \frac{1}{T}\frac{\delta^2 E}{\delta T \delta V} \tag{43}$$

Combining equation 17 (Part II) and 41 gives:

$$\left(\frac{\delta S}{\delta T}\right)_p = \frac{C_p}{T} = \frac{1}{T}\left(\frac{\delta H}{\delta T}\right)_p \tag{44}$$

Differentiating with respect to P gives the following relationship:

$$\frac{\delta^2 S}{\delta T \delta P} = \frac{1}{T}\left(\frac{\delta C_p}{\delta P}\right)_T = \frac{1}{T}\frac{\delta^2 H}{\delta T \delta P} \tag{45}$$

Equations 43 and 45 will be useful relations in developing other thermodynamic relations.

Carnot Cycle

Before continuing with the development of thermodynamic equations it is appropriate to consider the Carnot cycle, which not only contributes to the understanding of reversibility and entropy but also represents a useful tool in dealing with heat and work. There are two Carnot cycles, the power and refrigeration cycles. In the power cycle heat at a high temperature level is partially converted into work, the remaining heat being discarded at a lower temperature. In the refrigeration cycle work is supplied to take heat from a lower temperature to a high temperature level. These two cycles are of considerable importance in the study and application of thermodynamics as the Carnot cycle is a recognized standard of thermal efficiency.

Heat has been used as a source of mechanical power for two centuries. It has been the universal experience that the efficiency of conversion of heat into work is always low. Steam power plants have efficiencies of not more than 30 percent and internal-combustion engines not more than 40 percent. This is in sharp contrast to the well-recognized fact that work is always completely convertible to heat. One unfamiliar with the second law of thermodynamics might be inclined to explain the low efficiencies for the conversion of heat into work by assuming improper design and construction. But all efforts at increasing the efficiencies of this conversion have been fruitless and it was finally concluded that the low efficiencies were due to some fundamental underlying natural limitation governing the convertibility of heat into work. The impossibility of completely converting heat to work was first recognized by Carnot early in the 19th century. His great nomograph, published in Paris in 1824, laid the foundations of the second law of thermodynamics.

Every heat engine is inefficient because of friction or imperfect design; but even if all such sources of degradation are eliminated, no engine could be constructed to give a 100 percent conversion of heat into work. In order to obtain the maximum possible work from a heat engine, it would be necessary to eliminate friction, to prevent direct flow of heat from hot to cold portions of the system, and to maintain a state of balance with respect to the mechanical forces. In other words, the process must be reversible. The maximum possible conversion of heat into work occurs in an engine that operates reversibly in all its stages. Such an engine is the limit which may be approached by any actual engine as its design and construction are improved. If a heat engine operates reversibly, so that it is in the same state at the end of the operation as at the beginning, it will suffer no change of entropy. All the entropy changes must add up to zero.

This theoretical engine is known as the "Carnot engine" and the cycle of its operation is known as the "Carnot cycle." Figures 3 and 4 and Table 7 show the features of the power and refrigeration Carnot cycle.

Power Cycle. The Carnot cycle for the heat-power engine is shown by three diagrams in Figure 3 and described in Table 7. This cycle consists of four reversible processes or paths, as indicated. The cycle is theoretical and unobtainable in actual practice. The steam-power-plant cycle is an approach to this theoretical cycle. The four processes involved in the steam-power cycle are carried out in separate equipment, as indicated in Table 7. Only part of the heat supplied in the boiler can be converted to work. Some heat must be lost to the condenser and some will be lost by friction, radiation, conduction and convection. It is possible to reduce the latter losses by more efficient design. The Carnot cycle defines the limit in thermal efficiency that can be approached but not reached. The efficiency of the Carnot cycle will next be derived.

Consider the two isothermal processes 1-2 and 3-4 where the temperatures are T_2 and T_1, respectively. The change in entropy of the system accompanying the absorption of Q_2 units of heat at T_2 is Q_2/T_2, and the change of entropy accompanying the liberation of Q_1 units of heat at T_1 is $-Q_1/T_1$

TABLE 7

Description of Processes in Carnot Cycles and Equipment in Actual Cycles

Path	Carnot Cycle Processes	Description of Reversible Carnot Cycle Processes		Equipment Used in Actual Irreversible Cycles	
		Power (Fig. 3)	Refrigeration (Fig. 4)	Power	Refrigeration
1-2	Isothermal	Absorption of Heat	Liberation of Heat	Steam Boiler	Condenser
2-3	Isentropic	Adiabatic Expansion	Adiabatic Expansion	Turbine	Throttle Valve
3-4	Isothermal	Liberation of Heat	Absorption of Heat	Condenser	Coil in Brine Tank
4-1	Isentropic	Adiabatic Compression	Adiabatic Compression	Feed Pump	Compressor

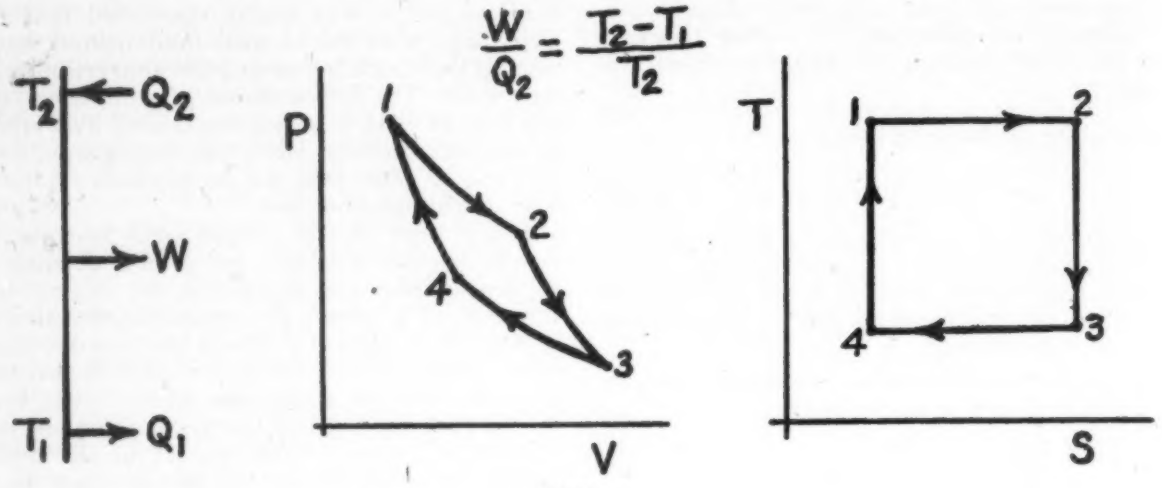

FIGURE 3

Carnot cycle for heat-power engine.

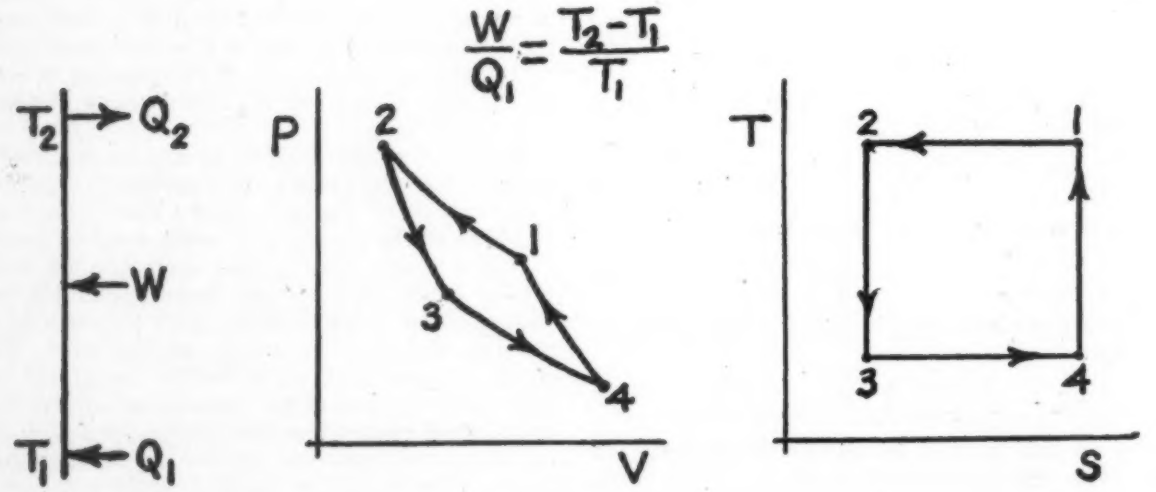

FIGURE 4

Carnot cycle for refrigeration machine.

Since this is a reversible cycle the sum of these entropy changes must equal zero, hence:

$$\frac{Q_2}{T_2} - \frac{Q_1}{T_1} = 0$$

By the conservation of energy law:

$$W = Q_2 - Q_1$$

Combining these equations gives:

$$\frac{W}{Q_2} = \frac{T_2 - T_1}{T_2} \qquad (46)$$

This equation shows the importance of the temperature in the heat sink or condenser.

Refrigeration Cycle. By reversing the power cycle the refrigeration cycle is obtained. The refrigeration Carnot cycle is shown by means of three diagrams in Figure 4 and described in Table 7. This cycle also consists of four reversible processes or paths as indicated and may be considered as theoretical and unobtainable in actual practice but nevertheless very

useful as a limit to approach. In refrigeration heat is transported from a cold reservoir to a hot reservoir by the expenditure of work. This is accomplished in four different items of equipment as indicated in Table 7. The Carnot efficiency for a reversible refrigeration cycle is found in the same way the Carnot efficiency was found for the power cycle above, giving:

$$\frac{W}{Q_1} = \frac{T_2 - T_1}{T_1} \qquad (47)$$

This equation is analogous to equation 46. The significance of these equations is obvious from Figures 3 and 4.

Heat can be absorbed or liberated by a fluid at constant temperature if the fluid is a pure compound and the process is one of vaporization or condensation. A refrigeration machine approaches these processes more closely than does a heat engine. In order to approach reversibility the expansion and compression processes would have to take place slowly with small differences in pressure. The compression process of a refrigeration machine approaches adiabatic (isentropic) closely in some cases.

Energy and Enthalpy

Very useful equations for the energy and the enthalpy may now be obtained by considering the case where the pressure within a system is an infinitesimal greater or lower than the pressure exerted upon the system, i.e. reversible expansion or compression. By equation 37 the heat absorbed by the system is TdS, while the work done by the system is PdV. By the first law of thermodynamics:

$$dE = TdS - PdV \qquad (48)$$

This is the general differential equation of the energy. Dividing this general equation through by dV and restricting it to an isothermal process gives:

$$P = T\left(\frac{\delta S}{\delta V}\right)_T - \left(\frac{\delta E}{\delta V}\right)_T \qquad (49)$$

Differentiating equation 49 with respect to temperature and with volume constant,

$$\left(\frac{\delta P}{\delta T}\right)_v = T\,\frac{\delta^2 S}{\delta T \delta V} + \left(\frac{\delta S}{\delta V}\right)_T - \frac{\delta^2 E}{\delta T \delta V} \qquad (50)$$

It was shown in equation 43 that the second and fourth terms are equal. Since they are of opposite sign in equation 50 they cancel, giving:

$$\left(\frac{\delta S}{\delta V}\right)_T = \left(\frac{\delta P}{\delta T}\right)_v \qquad (51)$$

By means of the third transformation given in Table 1, equation 51 is simplified to make it easier evaluated, giving:

$$\left(\frac{\delta S}{\delta V}\right)_T = -\frac{\left(\frac{\delta V}{\delta T}\right)_p}{\left(\frac{\delta V}{\delta P}\right)_T} \qquad (52)$$

Combining equations 49 and 51 gives the following thermodynamic equation of state:

$$P = T\left(\frac{\delta P}{\delta T}\right)_v - \left(\frac{\delta E}{\delta V}\right)_T \qquad (53)$$

from which the following equation for the isothermal effect of changes in volume on the energy can be computed:

$$\left(\frac{\delta E}{\delta V}\right)_T = T\left(\frac{\delta P}{\delta T}\right)_v - P \qquad (54)$$

In order to express the energy as a function of P, V, and T, eliminating entropy, the following differential equation is written from a strictly mathematical standpoint:

$$dE = \left(\frac{\delta E}{\delta T}\right)_v dT + \left(\frac{\delta E}{\delta V}\right)_T dV \qquad (55)$$

Combining this equation with equations 16 and 54 gives the following equation:

$$dE = C_v dT + \left[T\left(\frac{\delta P}{\delta T}\right)_v - P\right] dV \qquad (56)$$

Equations for the enthalpy may be developed in the same way. Differentiating equation 9:

$$dH = dE + PdV + VdP \qquad (57)$$

which when combined with equation 48 gives:

$$dH = TdS + VdP \qquad (58)$$

This is the general differential equation for the enthalpy. Dividing this general equation through by dP and keeping temperature constant results in the following equation, which is analogous to equation 49:

$$V = -T\left(\frac{\delta S}{\delta P}\right)_T + \left(\frac{\delta H}{\delta P}\right)_T \qquad (59)$$

Differentiating with respect to temperature with pressure constant:

$$\left(\frac{\delta V}{\delta T}\right)_p = -T\,\frac{\delta^2 S}{\delta P \delta T} - \left(\frac{\delta S}{\delta P}\right)_T + \frac{\delta^2 H}{\delta P \delta T} \qquad (60)$$

From equation 45 it can be seen that the second and fourth terms are equal. Since they are of opposite signs they cancel giving:

$$\left(\frac{\delta S}{\delta P}\right)_T = -\left(\frac{\delta V}{\delta T}\right)_p \qquad (61)$$

Combining equations 59 and 61 gives the following thermodynamic equation of state:

$$V = T\left(\frac{\delta V}{\delta T}\right)_p + \left(\frac{\delta H}{\delta P}\right)_T \qquad (62)$$

from which the isothermal effect of pressure on the enthalpy may be found, as follows:

$$\left(\frac{\delta H}{\delta P}\right)_T = V - T\left(\frac{\delta V}{\delta T}\right)_p \qquad (63)$$

The enthalpy may also be expressed as a function of P, V, and T, eliminating entropy, by first writing the following mathematical equation:

$$dH = \left(\frac{\delta H}{\delta T}\right)_p dT + \left(\frac{\delta H}{\delta P}\right)_T dP \qquad (64)$$

Combining with equations 17 and 63 results in the following very useful equation:

$$dH = C_p dT + \left[V - T\left(\frac{\delta V}{\delta T}\right)_p\right] dP \qquad (65)$$

If $(\delta P/\delta T)_v$ and $(\delta V/\delta T)_p$ can be computed from P-V-T data the isothermal effects of volume on energy and of pressure on enthalpy may be calculated from equations 54 and 63 respectively. With C_p and C_v the effect of temperature on the energy and

the enthalpy may be computed. If, on the other hand $(\delta E/\delta V)_T$ and $(\delta H/\delta P)_T$ are known experimentally, equations 53 and 62 give the form to which any empirical equation of state must conform. If the Joule-Thomson coefficient is determined experimentally, equation 25 may be used to compute $(\delta H/\delta P)_T$. Equation 24 for the Joule-Thomson coefficient may now be expressed in more practical form by means of equation 63 as follows:

$$\mu = -\frac{\left(\frac{\delta H}{\delta P}\right)_T}{C_p} = \frac{T\left(\frac{\delta V}{\delta T}\right)_p - V}{C_p} \qquad (66)$$

Entropy. A differential equation for the entropy as a function of pressure and temperature can now be derived by writing the following mathematical relationship:

$$dS = \left(\frac{\delta S}{\delta T}\right)_p dT + \left(\frac{\delta S}{\delta P}\right)_T dP \qquad (67)$$

By equation 61 the coefficient of dP,

$$\left(\frac{\delta S}{\delta P}\right)_T = -\left(\frac{\delta V}{\delta T}\right)_p ;$$

and by equation 44 the coefficient of dT,

$$\frac{C_p}{T} = \left(\frac{\delta S}{\delta T}\right)_p .$$

Upon substituting these terms in equation 67 the following differential equation is obtained for the entropy:

$$dS = \left(\frac{C_p}{T}\right) dT - \left(\frac{\delta V}{\delta T}\right)_p dP \qquad (68)$$

A similar equation may be derived by assuming entropy a function of T and V but it will not be as practical as equation 68.

Latent Heat of Vaporization

Equation 51 may be applied to the vaporization of a pure substance, in which process the liquid is in equilibrium with its vapor, to formulate an expression for the latent heat of vaporization. In this case $\delta S/\delta V = \Delta S/\Delta V$ where ΔS and ΔV are the increases in the entropy and the volume, respectively. Being at the vapor pressure it is possible to omit the restriction of constancy of volume. The process is an equilibrium one and therefore reversible, so $\Delta S = \Delta H_v/T$, where ΔH_v is the latent heat of vaporization. Equation 51 thus becomes:

$$\frac{dP}{dT} = \frac{\Delta S}{\Delta V} = \frac{\Delta H_v}{T\Delta V} \qquad (51a)$$

This equation, which is known as the Clapeyron equation, is limited to single-component systems where isothermal vaporization is also at constant pressure.

When hydrocarbon mixtures vaporize, either the temperature must increase or the pressure must decrease, both cannot remain constant. Equation 65, which may be applied at constant temperature or constant pressure or when both T and P change, should be used in computing the heat of vaporization for mixtures. Calculated latent heats of vaporization should be checked by experimental data for both single-and multicomponent systems.

Specific Heats

By means of equations 43 and 51 a differential equation for the isothermal effect of volume on C_v may be developed. Differentiating equation 51 with respect to temperature with volume constant:

$$\frac{\delta^2 S}{\delta V \delta T} = \left(\frac{\delta^2 P}{\delta T^2}\right)_v \qquad (69)$$

Combining equations 43 and 69

$$\left(\frac{\delta C_v}{\delta V}\right)_T = T\left(\frac{\delta^2 P}{\delta T^2}\right)_v \qquad (70)$$

In the same manner the isothermal effect of pressure on C_p may be obtained. Differentiating equation 61 with respect to temperature with pressure constant:

$$\frac{\delta^2 S}{\delta P \delta T} = -\left(\frac{\delta^2 V}{\delta T^2}\right)_p \qquad (71)$$

Combining equations 45 and 71:

$$\left(\frac{\delta C_p}{\delta P}\right)_T = -T\left(\frac{\delta^2 V}{\delta T^2}\right)_p \qquad (72)$$

Equation 72 is very useful in computing the effect of pressure on the specific heat, specific heats at higher pressures being used in heat-transfer calculations, etc.

By the first law of thermodynamics, equation 20 was developed for the difference in specific heats but this equation was left in an unpractical form. With the aid of the second law these equations may now be developed further. Combining equations 20 and 62 gives:

$$C_p - C_v = T\left(\frac{\delta P}{\delta T}\right)_v \left(\frac{\delta V}{\delta T}\right)_p \qquad (73)$$

Since the pressure-temperature coefficient is not ordinarily measured at constant volume, equation 73 may be simplified by means of the third transformation given in Table 1. Combining this transformation equation with equation 73 gives the following very useful equation for the difference in the specific heats:

$$C_p - C_v = -T\frac{\left(\frac{\delta V}{\delta T}\right)_p^2}{\left(\frac{\delta V}{\delta P}\right)_T} \qquad (74)$$

Equilibrium-Free Energies

A system is said to be in equilibrium when all the factors which determine the flow of energy or matter, either within the system or between the system and its surroundings, are exactly balanced. At equilibrium the pressure, temperature, and volume of a system are constant. The temperature throughout the system must be uniform and if the system is bounded by a heat-permeable wall, then the system and the immediate surroundings must have the same temperature. If a system is enclosed in a vessel with a movable piston, the pressure exerted by the system on the piston must be exactly balanced by the pressure exerted by the piston on the system. If gas is to be compressed in a vessel by a movable piston, there must be a difference between the pressures exerted by the piston and the gas. In order for this process to be reversible, there must be an infinitesimal difference in the pressure. Such a reversible process is also at equilibrium and occurs at constant entropy.

Not all constant-entropy processes are reversible and not all equilibrium processes occur at constant entropy. Examples are: the compression (not a reversible or equilibrium process) of gas may be made to occur at constant entropy by taking away just the right amount of heat, caused by friction, by

jacket-cooling water; and the flash vaporization of hydrocarbon mixtures is an equilibrium (phase) process but does not occur at constant entropy. Phase and chemical or reaction equilibria are the only type of equilibrium encountered in petroleum refining process design. Valuable equilibria relationships will be developed by the use of thermodynamics.

It has been shown that any actual or irreversible process is characterized by an increase in the total entropy of all systems concerned. Such a system is not at equilibrium but is subject to spontaneous change. A state of equilibrium is one in which every possible infinitesimal process is reversible, or one in which the total entropy remains constant. This is the most general criterion of equilibrium thermodynamics offers. As a matter of fact, it is too general because it is not always easy to evaluate the change in entropy. For this reason, two thermodynamic functions, which are less fundamental and less general than the entropy, have been invented for practical convenience. In terms of quantities already employed, the two free-energy functions are defined as follows:

$$A = E - TS \tag{75}$$

and

$$F = H - TS \tag{76}$$

The first is known as the Residual Work or the Helmholtz free energy and the second is known as the Free Energy or the Gibbs free energy. On combining equation 19, which states $H = E + PV$, with equation 75 and 76 the following relation between A and F results:

$$F = A + PV \tag{77}$$

Equation 77 shows that F and A bear the same relation to each other as H and E. Changes in the quantity A represent the maximum *possible work* for a system, which is the work for an isothermal reversible process. In other words, ΔA is the limit of the work which can be performed by an isothermal process as its efficiency is indefinitely improved. Changes in the quantity F represent the maximum *net work* for a system, which is the work for an isothermal reversible process that is also isobaric. In any process occurring at constant pressure and temperature, ΔF represents the maximum amount of work which can be obtained and applied to useful purposes. For this reason F is known simply as "Free Energy." The free energy is one of the most useful thermodynamic potentials.

Expressions for A and F in temperature and pressure are derived from equations 75 and 76. Differentiating equation 75 with respect to volume, temperature constant,

$$\left(\frac{\delta A}{\delta V}\right)_T = \left(\frac{\delta E}{\delta V}\right)_T - T\left(\frac{\delta S}{\delta V}\right)_T \tag{78}$$

Equation 49 states that:

$$\left(\frac{\delta E}{\delta V}\right)_T - T\left(\frac{\delta S}{\delta V}\right)_T = -P \tag{49}$$

whence for an isothermal process:

$$\left(\frac{\delta A}{\delta V}\right)_T = -P \tag{79}$$

Starting with equation 75 again and differentiating with respect to temperature, volume constant,

$$\left(\frac{\delta A}{\delta T}\right)_V = \left(\frac{\delta E}{\delta T}\right)_V - T\left(\frac{\delta S}{\delta T}\right)_V - S \tag{80}$$

The second and third terms are both equal to C_v by equations 16 and 42 and, therefore, cancel giving:

$$\left(\frac{\delta A}{\delta T}\right)_V = -S \tag{81}$$

Combining equations 79 and 81:

$$dA = -PdV - SdT \tag{82}$$

A similar equation may be developed for F in the same manner. Differentiating equation 76 with respect to pressure, temperature constant,

$$\left(\frac{\delta F}{\delta P}\right)_T = \left(\frac{\delta H}{\delta P}\right)_T - T\left(\frac{\delta S}{\delta P}\right)_T \tag{83}$$

Combining with equation 59:

$$\left(\frac{\delta F}{\delta P}\right)_T = V \tag{84}$$

Integrating equation 84 gives:

$$(\Delta F)_T = F_2 - F_1 = \int_1^2 V dP \tag{85}$$

Starting again with equation 76 and differentiating with respect to temperature, pressure constant:

$$\left(\frac{\delta F}{\delta T}\right)_P = \left(\frac{\delta H}{\delta T}\right)_P - T\left(\frac{\delta S}{\delta T}\right)_P - S \tag{86}$$

but the second and third term are each equal to C_p by equations 17 and 44 and therefore cancel giving:

$$\left(\frac{\delta F}{\delta T}\right)_P = -S \tag{87}$$

Combining equations 84 and 87:

$$dF = VdP - SdT \tag{88}$$

Thermodynamic Potentials

To recapitulate the following four thermodynamic potentials have been defined.

Residual Work:	$A = F - PV$
	$A = E - TS$
Free Energy:	$F = A + PV$
	$F = H - TS$
Internal Energy:	$E = A + TS$
	$E = H - PV$
Enthalpy:	$H = A + TS + PV$
	$H = F + TS$
	$H = E + PV$

The following basic differential equations have been derived for these potentials.

Residual Work	$dA = -PdV - SdT$	(82)
Free Energy	$dF = +VdP - SdT$	(88)
Internal Energy	$dE = -PdV + TdS$	(48)
Enthalpy	$dH = +VdP + TdS$	(58)

The analogy existing between these equations should be noted.

The equations for the internal energy and the enthalpy have been transformed to give more useful expressions.

$$dE = C_v dT + \left[T\left(\frac{\delta P}{\delta T}\right)_V - P \right] dV \tag{56}$$

$$dH = C_p dT + \left[V - T\left(\frac{\delta V}{\delta T}\right)_P \right] dP \tag{65}$$

These equations contain two terms, one showing the effect of temperature on the energy or enthalpy and the other showing the effect of volume or pressure on energy or enthalpy. These thermodynamic potentials are presented in Table 3 of Part I.

End of Part III; Part IV will appear in the next issue.

Insulation Data On a Large Combination Unit

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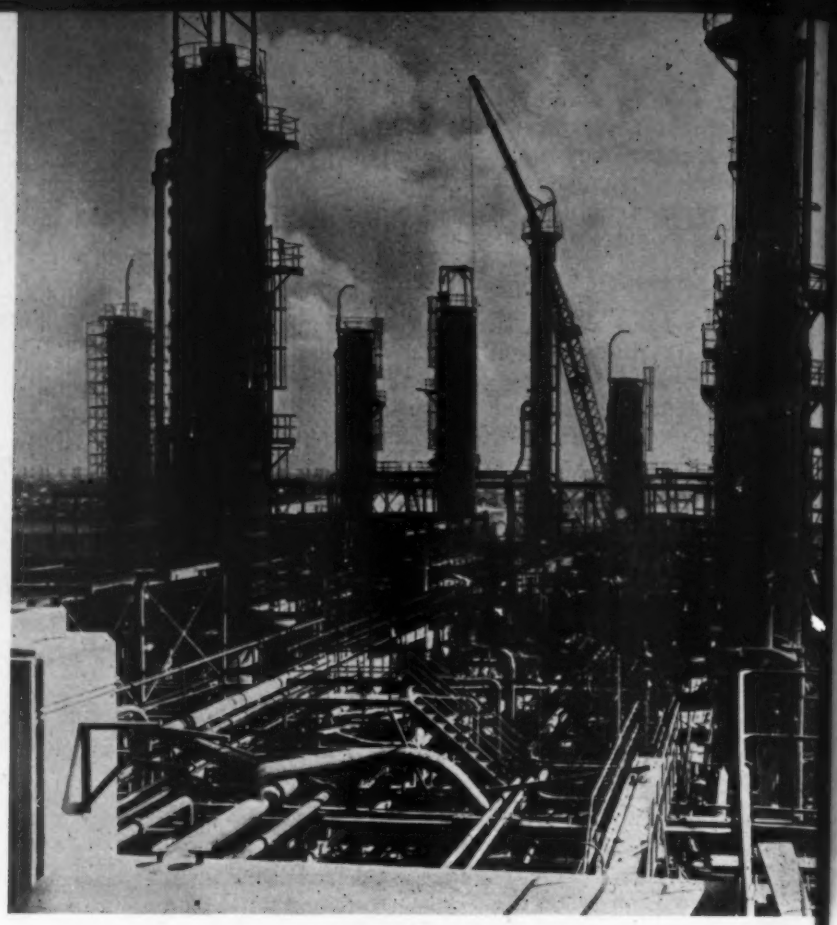


Bubble towers for handling furnace effluent cracking streams and for production of gasoline and fuels at the Wilmington, California, plant of Union Oil Company.

DURING World War II, The Lummus Company designed and constructed a combination distillation, cracking, and polyform unit for Union Oil Company at Wilmington, Calif. The unit, the largest of its type ever built, is designed to produce nine individual cuts from 46,500 barrels per operating day of Los Angeles Basin crude. The basis for design of the unit is listed in Table 1.

In the crude section the lighter of the nine cuts, which constitute different grades of gasoline and kerosine as well as toluene stock, are withdrawn from the unit when they are properly separated. The heavier cuts are prepared in the topping section for feed to the cracking section.

Charging stocks for the cracking heaters are segregated according to their boiling range and refractivity so that they can be successively treated under more severe cracking conditions. The ultimate goal in the cracking section is to produce fuel oil with a furol viscosity of 125 at 122° F., and 400° F. end point, 10-pounds RVP gasoline, or, upon recracking the gasoline, to produce a maximum of olefine stocks for feed to an alkylation unit.

When operated for maximum production of motor gasoline, the final product is withdrawn from the bottom of a stabilizer. When operated for gas production, the stabilizer bottoms are further fractionated to remove the butanes and pentanes and then the naphtha is prepared for recracking.

The entire unit is so constructed that there is one topping section, one gas distillation section, and two identical cracking sections. That means that half the cracking unit can be down while the crude section is being operated at less than full capacity.

With process temperature as high as 1000° F., and because of the size and extent of the equipment

TABLE 1—BASIS FOR DESIGN

STRAIGHT RUN CUTS

Products

MATERIAL	Boiling Range	API
Aviation Blend Stock	I.B.P. 200 F.	63
Toluene Stock	200 F. 260 F.	53.5
Heavy Gasoline	260 F. 380 F.	46.5
Kerosene	380 F. 450 F.	39.5
Kerosene	450 F. 500 F.	36.5

Cracking Stock

MATERIAL	Boiling Range	API
Gasoil	400 F. 600 F.	33.5
Gasoil	600 F. 700 F.	29.0
Heavy Gasoil	700 F. 825 F.	24.6
Reduced Crude	825 F. plus	11.4

Cracked Products

Case I

MATERIAL	Specifications
Motor Gasoline Fuel Oil	400 F E.P. 7-9 API—Viscosity. 125 Furol at 122 F.

Cracked Products

Case II

MATERIAL	Specifications
Total Butanes plus Butylenes	Substantially C_5 free with at least 955 B/OD Butylenes.
Total Pentanes plus Amylenes	Substantially C_6 free with at least 650 B/OD Amylenes.
Fuel Oil	7-9 API Viscosity 125 Furol at 122 F.

involved, careful attention was given to the type, thickness, and method of application of heat insulation. (Sizes and operating temperatures of the major pieces of equipment are listed in Table 2.) All equipment, such as columns, exchangers, heaters, lines and pumps carrying oil, vapors, or steam were insulated to conserve heat, maintain temperature controls, and prevent operators from getting burned on hot lines or equipment that may be reached or touched.

TABLE 2—TOWERS

Crude Section

NAME	No. of Units	DIMENSIONS Inside Dia.	DIMENSIONS Total Height	Operating Temperature °F. (Max.)	Operating Pressure (Max.) psi
Crude	1	14′-0″	124′-5″	700	60
Rerun	1	9′-0″	84′-6″	355	60
Reduced Crude Vacuum	1	16′-0″	116′-6″	Top 400 Flash 725 Bot. 725	Top 180 MM Flash 200 MM
Naphtha Stripper	1	4′-0″	28′-0″	545	59
Light Kero	1	4′-0″	28′-0″	545	59
Heavy Kero Stripper	1	4′-0″	28′-0″	545	59
Gasoil Stripper	1	6′-0″	34′-0″	600	195 MM
Heavy Diesel Stripper	1	6′-0″	34′-0″	500	190 MM
Light Diesel Stripper	1	6′-0″	34′-0″	400	185 MM

Cracking Section

NAME	No. of Units	DIMENSIONS Inside Dia.	DIMENSIONS Total Height	Operating Temperature °F. (Max.)	Operating Pressure (Max.) psi
High Pressure Evaporator	2	9′-0″	54′-8″	800	400
Bubble Tower	2	9′-9″	111′-6″	710	390
Low Pressure Evaporator	2	7′-0″	50′-2″	900	30
Fuel Oil Vacuum	1	11′-6″	82′-6″	775	200 MM
Blend Oil Stripper	2	4′-0″	29′-2″	600	180
Stabilizer	1	10′-6″	82′-3″	465	375
Absorber	1	6′-0″	103′-0″	120	365

Gas Fractionation Section

NAME	No. of Units	DIMENSIONS Inside Dia.	DIMENSIONS Total Height	Operating Temperature °F. (Max.)	Operating Pressure (Max.) psi
Debutanizer	1	9′-0″	77′-0″	420	135
Debutanizer	1	8′-0″	81′-0″	Top 185 Feed 270 Bot. 330	50
Gasoline Rerun	1	9′-0″	63′-0″	320	8

TABLE 3—INSULATION FOR OIL VESSELS

TEMPERATURE	Thickness	Material
600 F. or less	2 in.	85% Magnesia
600 F.—750 F.	1½ in.	85% Magnesia
	1½ in.	Diatomaceous silica
750 F. and above	2 in.	85% Magnesia
	2 in.	Diatomaceous silica

Insulation of the Equipment

Eighty-five percent magnesia was used as insulation for all equipment operating at a temperature of 600° F. or less. This material is a mixture consisting of 85 percent basic magnesium carbonate combined with asbestos fiber, and takes the form of blocks or pipe insulation. In addition to having a low thermal conductivity, it has sufficient mechanical and structural strength so that it can be handled and applied without excessive breakage, and can withstand equipment vibration without disintegrating.

For temperatures above 600° F., an inner layer of diatomaceous silica was used under the 85 percent magnesia.

Insulation thicknesses were chosen on the basis of equipment, size, operating temperatures, etc., and, with certain exceptions discussed below, are listed in Tables 3 and 4.

The insulation was applied and finished as follows:

1) *Oil Vessels Below 600° F.* The 85 percent magnesia was secured in place with ¾-inch steel bands spaced 2 feet apart, and a ¼-inch scratch coat of an asbestos cement was applied. When the scratch coat was thoroughly dried, 1-inch mesh, 20-gauge galvanized hexagonal wire was applied, drawn taut with all the edges thoroughly laced and wired in place and nailed with staples to the insulation. The wire was covered with a ¼-inch coat of weatherproofing cement troweled to a smooth, even surface. The scratch and finish coats were applied while the vessels were still hot and expansion joints were provided in both coats at every insulation support to allow for the longitudinal expansion of the vessel.

2) *Oil Vessels Above 600° F.* Instead of a final weath-

TABLE 4—INSULATION FOR PIPING

The thickness given is that of the insulation and does not include protective finish.

Temperature, °F.	Pipe Sizes Larger Than 4″ Thickness	Pipe Sizes Larger Than 4″ Material	Pipe Sizes 2″ to 4″ Incl. Thickness	Pipe Sizes 2″ to 4″ Incl. Material	Pipe Sizes Under 2″ Thickness	Pipe Sizes Under 2″ Material
Hot Water	Standard	85 percent Magnesia	Standard	85 percent Magnesia	Standard	85 percent Magnesia
222– 266	Standard	85 percent Magnesia	Standard	85 percent Magnesia	Standard	85 percent Magnesia
267– 337	1½″	85 percent Magnesia	Standard	85 percent Magnesia	Standard	85 percent Magnesia
338– 387	2″	85 percent Magnesia	1½″	85 percent Magnesia	Standard	85 percent Magnesia
388– 600	Double Std.	85 percent Magnesia	2″	85 percent Magnesia	1½″	85 percent Magnesia
601– 700	*	Diatomaceous silica	*	Diatomaceous silica	2″	Diatomaceous silica
	2″	85 percent Magnesia	1½″	85 percent Magnesia		
701– 800	*	Diatomaceous silica	*	Diatomaceous silica	2″	Diatomaceous silica
	2½″	85 percent Magnesia	2″	85 percent Magnesia		
801– 900	*	Diatomaceous silica	*	Diatomaceous silica	2″	Diatomaceous silica
	2″	85 percent Magnesia	1½″	85 percent Magnesia		
901–1000	*	Diatomaceous silica	*	Diatomaceous silica	2″	Diatomaceous silica
	2″	85 percent Magnesia	1½″	85 percent Magnesia		
1001–1200	*	Diatomaceous silica	*	Diatomaceous silica	2½″	Diatomaceous silica
	2″	85 percent Magnesia	1½″	85 percent Magnesia		

NOTES—Standard thickness of 85 percent Magnesia for pipes ½″ to 1½″ incl. = ⅞″; 2″ to 3½″ incl. = 1 ⅛″; 4″ to 6″ incl. = 1½″; 7″ to 10″ incl. = 1¼″; 12″ to 30″ incl. = 1½″.

* These thicknesses of diatomaceous silica are applied to each pipe size as follows:

Temperature, °F.	2″	2½″	3″	4″	6″	8″	10″	12″
601– 800	1¼″	1 ⅛″	1 ⅛″	1 ⅛″	1½″	1½″	1 ⅛″	1 ⅛″
801–1000	2⅛″	1 ⅞″	2 ⅛″	2 ⅛″	2 ⅛″	2″	2⅛″	2⅛″
1001–1200	2⅝″	2⅝″	2 ⅝″	2 ⅝″	2 ⅝″	2 ⅛″	2⅝″	2⅝″

erproof cement coating as above, a sheath of sheet metal was used. The sheath consists of 22-gauge galvanized sheet metal fabricated to enclose the insulation completely. Expansion joints with spring-loaded bolts were provided to compensate for circumferential expansion. Longitudinal expansion of the sheath was provided by lap seams at intervals of 12 feet. Otherwise the finish is the same as for (1).

3) *Oil, Vapor, and Steam Lines.* The finish for these lines is similar to that described in (1), except that the insulation was secured in place with No. 12 black annealed wire spaced about 9 inches apart. Insulated lines in locations where the insulation may be damaged or broken, and all lines operating at temperatures above 600° F. were covered with 26-gauge galvanized sheet metal, wired on with 12-gauge galvanized wire spaced 6 inches apart.

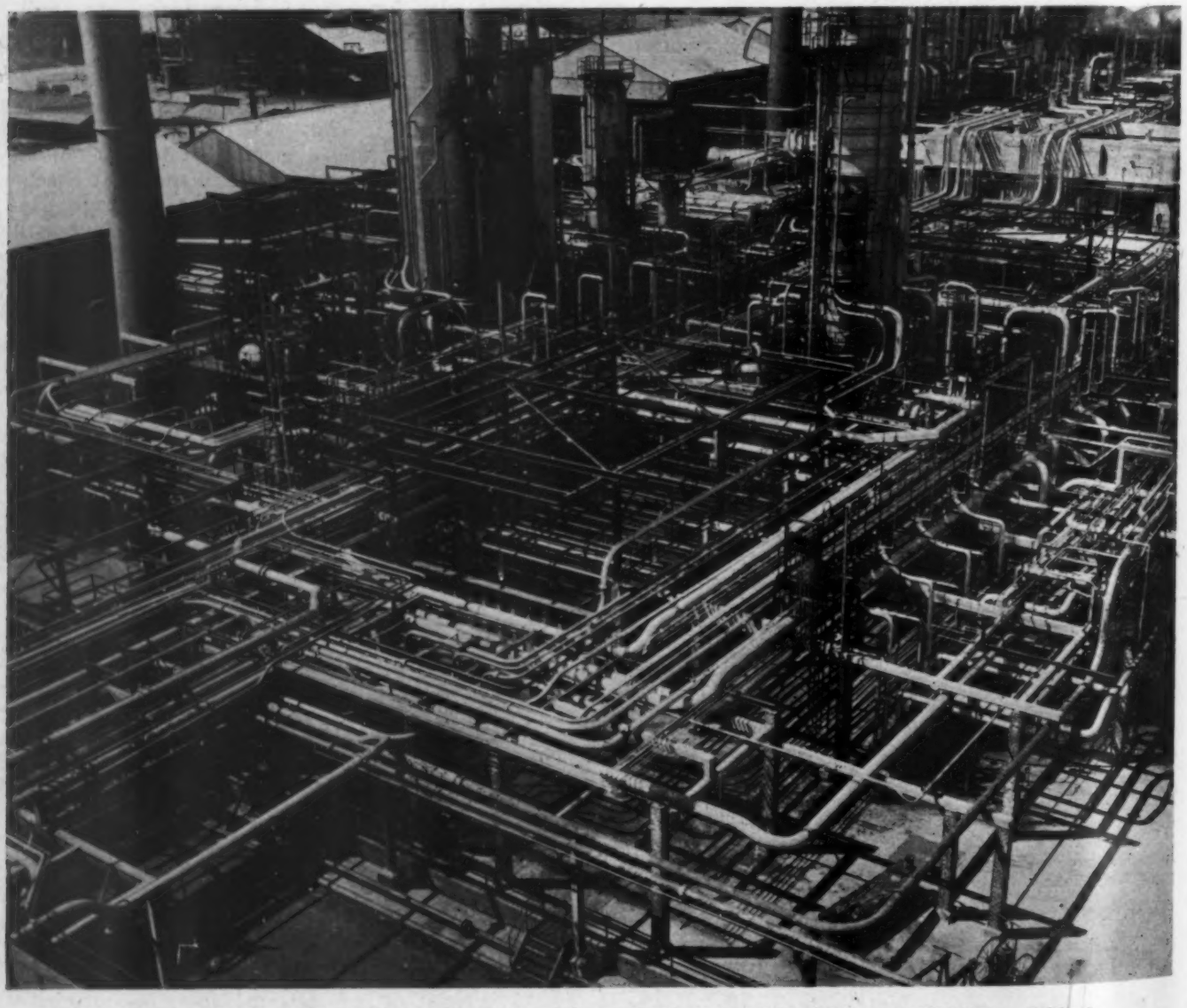
4) *Exchangers.* Heat exchangers that operate at 600° F. or less in the shell passes were insulated with 1½-inch thick magnesia block. Those that operate at more than 600° F. in the shell passes were insulated with a layer of diatomaceous silica insulation and a 1½-inch layer of magnesia block. The insulation was finished in accordance with the temperature classification as given above for oil vessels.

5) Insulation on the *cover plates or heads of the partial condensers and interchangers* was cut back or relieved so that the bolts can be removed without disturbing the insulation. Insulation lined sheet metal covers were provided for the heads of shell and tube bundles that must be opened frequently for cleaning.

6) *Pumps.* Certain pumps which require frequent maintenance work were equipped with removable insulation, covered with a sheet metal jacket of 18-gauge steel and flanged to permit removal.

With the exception of those flanges that may be touched by operators while working, the insulation on all equipment was cut back or relieved at flange connections so that flange bolts can be tightened without disturbing the insulation. To prevent insulation from slipping, 1-inch x 1-inch x ⅛-inch support angles were provided on vertical lines more than 10 feet in length, staggered on opposite sides of the pipe, and placed at 6-foot intervals.

All insulation on vessels or columns was provided with light circumferential angle supports spaced 6 feet apart on vessels operating at temperatures over 600° F. and 12 feet apart on vessels at temperatures under 600° F.



View of magnesia insulated piping in the cracking section of the combination unit at Union Oil Company, Wilmington, California.

The Instrumentation of Cycling Plants

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FUTURE development of instrumentation methods are based on applications that have proven satisfactory in the past, because those points in the instrumentation system responsible for difficulties have been found during operation and corrected. In this paper, the author discusses the instrumentation system of a hypothetical cycling plant using standard controls, and emphasizes those points, often overlooked, that cause trouble in plant operation.

This paper was presented at the Second Annual Short Course on "Instrumentation for the Process Industries" held at Texas A. & M. College, August 27-29, and will be published in the bulletin of the proceedings.

THERE are very few principles in engineering that are not subject to wide variations in application so that the final selection of the details is usually a matter of personal preference. This is particularly true of instrumentation. With this in mind a hypothetical plant flow sheet has been selected showing methods of control that have proved satisfactory in the past. The methods shown are selected for their simplicity with the hope that in the general discussion other, and the more complicated, methods of obtaining similar results will be brought out.

The controls indicated on the flow sheet are more or less standard, but there are some points that are often overlooked that may cause trouble in plant operation. These will be pointed out and the method of overcoming at least in part the difficulties. Also a few safety devices will be mentioned.

With reference to this flow sheet (Figure 1), the plant pressure is controlled by a pressure reducing valve on the incoming well stream fluid. This valve is handling a mixture of liquid and gas and so is subject to severe erosion. To combat this the valve selected should be streamlined as much as possible and have the plug and seats faced with some hard material such as stellite. As this valve has a high thrust on the stem at all times, due to the high working pressure of the valve, a very large diaphragm is required to supply the power to overcome this load. In the usual motor valve the stem is made small in order to reduce friction in the packing gland. Due to the high thrust on this valve the stem must be large, otherwise it would bend with the severe load imposed upon it. An angle type valve with the fluids entering the side connection between the packing gland and the plug, and leaving through the bottom connection, is sometimes used. This tends to balance the thrust on the stem with the drag on the plug. To prevent leaking around the stem the stuffing box must be deep and kept tight, thereby introducing considerable friction. To overcome the effects of friction, drag and thrust, the valve should be equipped with a valve positioner.

High Differential Valves

Motor valves that operate with a high differential, that is over 300 pounds, and handle liquids or a mixture of liquids and gas, should usually be hard faced to keep from having the seats and plugs cut out. Valves on the flow sheet that would come into this class include: the liquid level control valves on the gas distillate separator, the rich oil liquid level control valve on the main high pressure absorber, the liquid level control valves on the high pressure and intermediate pressure flash tanks, and liquid level control valve on the high pressure reabsorber.

If for any reason the liquid level control valve on the base of the main absorber fails to let the rich oil flow from the main absorber fast enough, the oil level will build up and before long the main absorber would puke. One method of overcoming this difficulty is to place another liquid level controller above the primary liquid level float. This upper controller actuates a motor valve in the lean oil line to the absorber so that if an excessively high level is encountered the lean oil flow is reduced or stopped.

If due to a surge of gas through the absorber or other causes, oil is carried overhead from the main absorber, it is collected in the main absorber residue scrubber. If the liquid level control valve cannot release this oil as fast as accumulated, a high level shut-down control and alarm is connected to either the ignition or fuel system of the engines so that there is little or no danger of getting liquid into the compressor cylinders. Although the liquid level con-

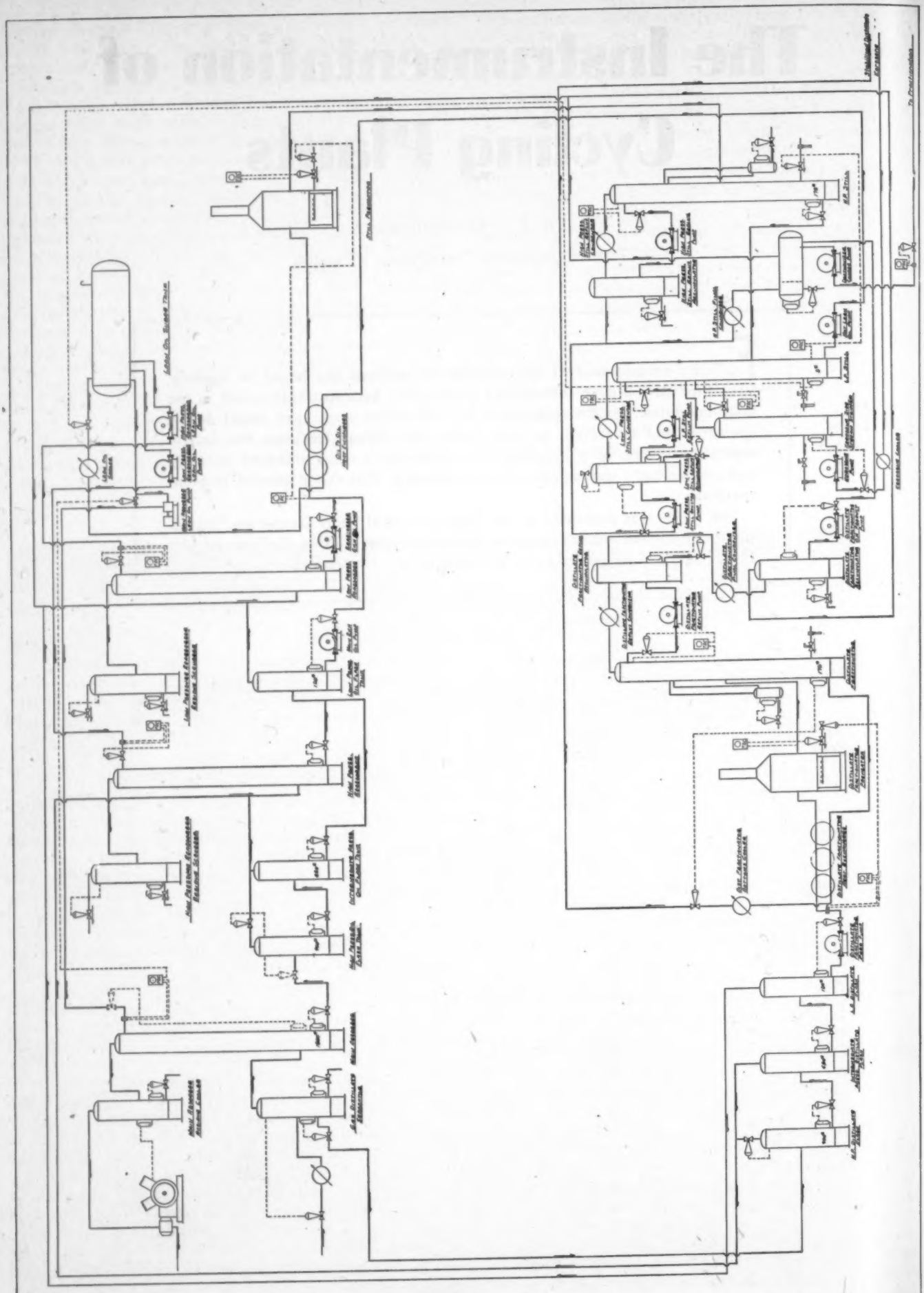


FIGURE 1

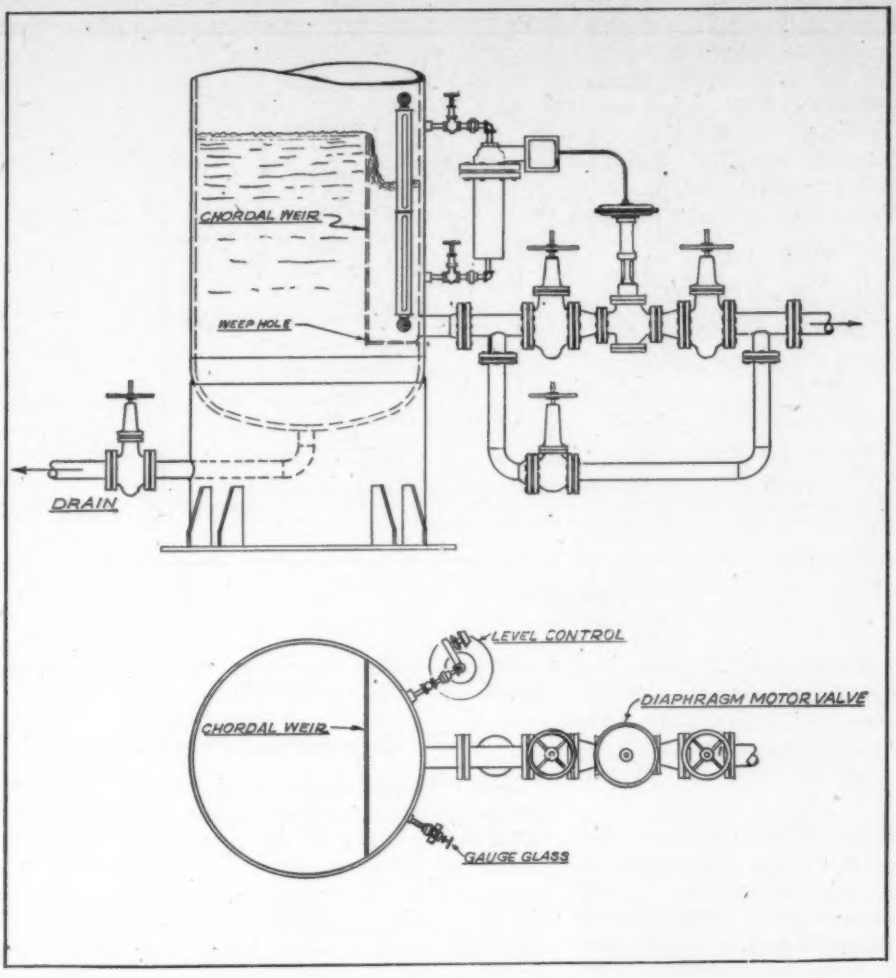


FIGURE 2

Method of increasing sensitivity of liquid level control valves.

trol value on the main absorber outlet scrubber has a high differential across it, it is not usually hard faced, as it cannot be classed as a throttling controller, since it is used only as a dump valve in case of carry-over from the absorber. This same comment applies to all valves used in similar service.

If for any reason the liquid level control valve on the high pressure absorber does not function properly and allows all the oil to be drained from the main absorber, a large volume of gas would pass into the high-pressure flash tank. This volume of gas might easily exceed the vapor relief system of this vessel. To prevent this, sometimes a pressure reducing valve is placed in the line between the high pressure absorber and the flash tank. This pressure reducing valve is set at a slightly higher pressure than the normal operating pressure of the flash tank so that if an excessive volume of gas enters the flash tank, this valve will throttle or completely close till the trouble has been repaired.

Even Flow Required

The efficient operation of the oil to oil heat exchangers, still preheater, and stills, depends on an even flow of oil, free from surges. As the main oil flow is controlled by liquid level control valves these must be very sensitive. There are two ways the sensitivity of these valves can be increased. One is by the use of valve positioners on the motor valves and the other is by the method shown in Figure 2. Normally, to allow sufficient time to break the foam and disengage entrained gas the flash tanks are large. Therefore, a small change in level means a large volume of liquid either stored or released. If, however, a relatively small compartment on one side of the vessel is provided into which the liquid level control and outlet line are connected, into which the liquid in the main vessel overflows, the same change in level in the compartment will mean a relatively small change in rate. Without these small compartments in the absorbers and flash tanks, a surge started at the absorber is magnified as we pass through the system and may become so great as to materially effect plant efficiency. The same comments apply to the distillate fractionation system.

The protection of the direct-fired heaters against stoppage of flow of oil is very important. Two methods are shown on the flow sheet. The method shown on the still preheater is pressure controlled. Here advantage is taken of the pressure drop through the heat exchangers and heater to maintain a higher pressure at the inlet of the heat exchangers than is maintained in the still. This pressure controller is set at a slightly higher pressure than is normally carried on the still and at a lower pressure than normally exists at the heat exchanger inlet. Then if the oil rate decreases materially or stops, the pressure at this point falls and the fuel to the heater is cut off. The motor valve used for this purpose should be the type that requires hand resetting once it is closed. The other method as shown on the distillate fractionator preheater replaces the pressure controller with a flow rate controller set to trip the motor valve when the flow falls below a predetermined value. In either case the main temperature control can be used instead of a separate valve by using a motor valve

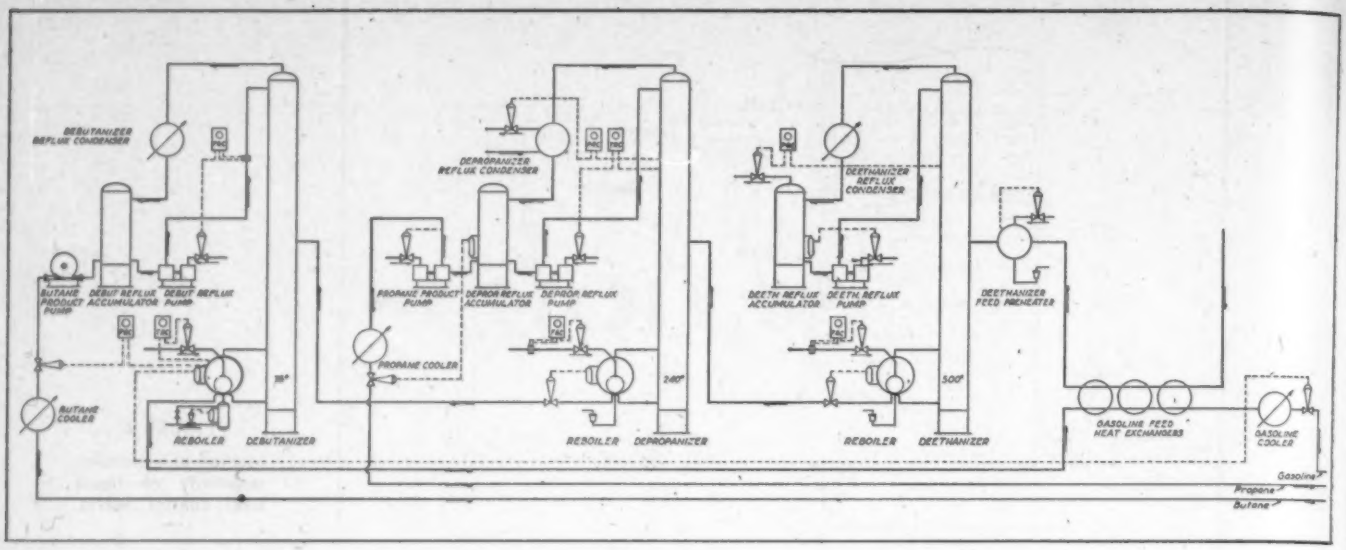


FIGURE 3

relieving to atmosphere on the air supply line between the temperature control instrument and its motor valve. When the safety controller trips this valve, the air pressure on the diaphragm of the temperature control valve is bled off and this valve closes.

The control system shown around the low and high pressure still is one that is not common use but has proved its reliability and efficiency. In the high pressure still it is desired to only strip the oil of enough of the light constituents so that total condensation will result at the operating pressure and temperature of the low pressure still condenser. As the condensation in the low-pressure still condenser is a function of temperature, with a constant stripping in the high-pressure still the low-pressure still pressure would vary. The stripping in the high-pressure still is a function of the amount of steam used. Therefore a pressure controller on the low pressure still controlling the steam rate to the high-pressure still will maintain a constant pressure in the low-pressure still with total condensation of the low-pressure still overhead at all times.

In cycling plants operating with high-pressure absorbers, a considerable amount of kerosine is carried into the absorbers in the vapor phase. This kerosine is absorbed in the absorption oil. If not removed it will build up in the oil to the point where the loss of kerosine in the lean gas is considerable. One of the easiest ways to remove this kerosine from the oil is by the use of a side-stream stripper on the low-pressure still. This side-stream stripper can only control the initial boiling point of the kerosine by the amount of steam introduced, so the liquid withdrawn into the stripper must be of the correct end point. The control of this end point is determined by the amount of reflux that passes down the column below the draw off point. This reflux in turn determines the tray temperature below this draw off point. If too much reflux is drawn off to the side-stream stripper, the column below the draw off point will increase in temperature; likewise if insufficient liquid is drawn off, the temperature will fall. Therefore a temperature controller controlling the temperature of the second or third tray below the draw off tray by controlling the amount drawn off to the stripper will define the end point of this product. This is based on the assumption that a constant amount of steam is introduced into the main column.

Conventional Pump Controls

The controls on the pumps are conventional. It is assumed that in showing the control system on the main absorber lean oil pump that it is an electric motor or other constant speed drive of a displacement pump. In this case any excess liquid handled by the pump must be by-passed back to the pump suction. As this valve has a high differential across it, it should be hard faced, and as there is a high thrust on the stem a valve positioner should be used.

Figure 3 shows a fractionating system, adaptable to the plant, producing propane, mixed butanes and a constant vapor pressure gasoline containing some butane. The system shown is commonly referred to as the cascade system in that the final gasoline passes through all the column in series.

The de-ethanizer is controlled without the use of a temperature controller. All the overhead product that condenses in the reflux accumulator is pumped back to the column. This reduces to a minimum the propane loss. The kettle is heated with a constant flow of steam so that this temperature automatically assumes its correct value. If sufficient heat is introduced to the kettle the bottoms will be stripped of methane and substantially all of the ethane. Increasing the heat input to this column will not increase the kettle temperature provided the column and reflux condenser are not overloaded.

If the heat exchanger on the de-ethanizer feed does not raise the temperature of the feed sufficiently, a preheater will be necessary. The type shown is satisfactory if the propane content of the feed is not high. The type shown is the simplest and consists only of maintaining a constant heating steam pressure on the unit.

The depropanizer control shown is one that is used quite extensively where it is desired to produce overhead from a column a pure product such as in depropanizers, de-isobutanizers, and de-isopentanizers. Here again the kettle temperature is not controlled but sufficient heat is introduced to strip the bottoms. The amount of reflux is controlled by the temperature at a point between the feed and column top. This point, in a depropanizer, should be the point

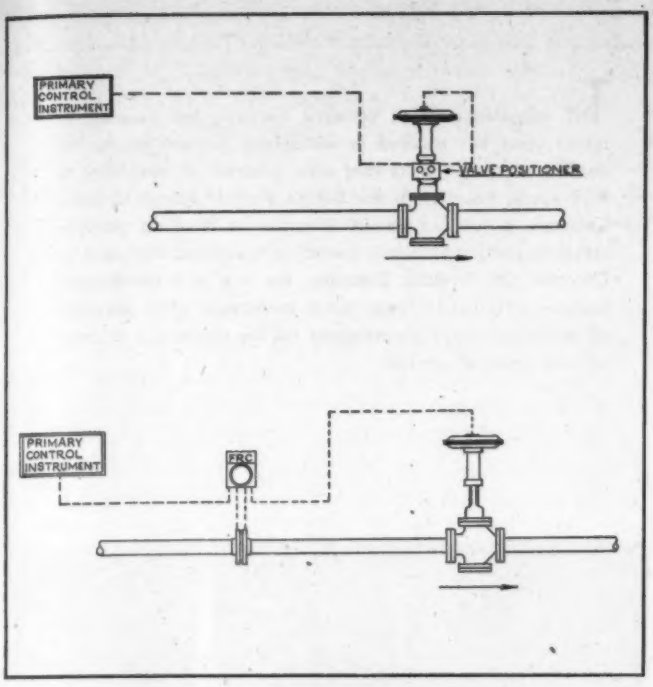


FIGURE 4
Method of controlling liquid rates

in the column where the isobutane content of the vapors, and consequently the temperature, is changing rapidly from tray to tray.

The pressure control system shown indirectly controls the temperature of the overhead product and therefore its vapor pressure, in the reflux accumulator. By using a valve positioner on the water control motor valve, very satisfactory pressure control can be obtained provided the water pressure is not subject to rapid and wide variations.

Overhead Products Pump

As the propane storage pressure is a function of temperature and may at times exceed the column pressure and at times be less than column pressure it is well to provide an overhead products pump. If a reciprocating pump is used, as shown, a pump pressure governor should be used with a liquid level operated motor valve in the pump discharge. If the liquid level motor valve were put in the steam supply to the pump all control of level would be lost when the storage pressure were less than column pressure.

A number of people object to the use of a pump governor. If so, the liquid level control valve can be placed in the steam supply to the pump and a back pressure regulator placed in the pump discharge line. This back-pressure regulator is set at a higher pressure than the column pressure.

The pressure control system shown on the debutanizer depends on the condensation of the overhead being governed by the amount of reflux condenser surface exposed to vapors. If the pressure increases, the liquid level back up in the reflux condenser falls, increasing the condensation. Conversely, if the pressure falls the liquid rises in the reflux condenser, decreasing the condensation surface. It is obvious from this that the net overhead product must be relatively large in order for this control method to be sensitive. One objection to this method of control is that the reflux is subcooled below its condensation temperature and its temperature varies with the load on the reflux condenser and cooling water temperature. With varying reflux temperature and a constant volume of reflux, the internal reflux in the column will vary causing a changing load condition on the column and reboiler.

As we are producing a constant vapor pressure bottom product, the temperature control is placed in the kettle. The temperature and pressure at this point define the vapor pressure of the product. The reflux control is the conventional constant volume type.

Withdrawing Steam Condensate

Two different methods of withdrawing steam condensate from the kettle are shown. One with the inverted bucket type trap and the other with a liquid level control and motor valve. The inverted bucket type trap is entirely satisfactory provided the line from the kettle to the trap is large enough and the trap set well below the tube bundle so that the tubes are well drained. The inverted bucket trap should be protected against dirt as a small amount of grit or scale will plug the orifice. This type of trap has the advantage of removing all fixed gases and keeping the tubes from becoming gas bound.

The liquid level control method of withdrawing condensate has the advantage of being able to put a gauge glass on the water, making possible a visual check of its operation. A small line should be installed from the top of the water leg to the down stream side of the motor valve so that fixed gases can be periodically withdrawn.

Alternate Liquid Rate Control Method

Figure 4 shows another method of control of liquid rates than that referred to above. In this alternate method the primary control instrument, temperature, pressure or liquid level, resets a flow rate controller in the liquid stream. Usually with this method a valve positioner is not required as the automatic reset feature of the flow rate controller takes care of this. One place where this method would be far preferable to the use of a valve positioner alone would be in the pressure control system shown on the depropanizer if the water pressure were subject to wide and sudden variations. Here the flow rate controller would correct the rate of flow before any measurable change in pressure in the system had been produced.

In general a primary control instrument resetting a flow rate controller will not give closer control than a primary control instrument working into a valve positioner. It will give better control in special cases as cited above.

As a general rule, valve positioners should be used on all temperature and pressure control valves where close temperature and pressure control are necessary to the proper functioning of the process and on all liquid level control valves where a sudden rate change, due to sticking of the valve, might upset the operation of a column.

In this paper no attempt has been made to cover all the control methods and problems that can come up, but is a general discussion of some of the most common methods.

Simplified Catalytic Cracking Unit

THE importance which catalytic cracking has assumed in recent years has resulted in widespread interest among the smaller refiners in units that offer prospect of suitability to their needs. Recently, at the Detroit plant of Aurora Gasoline Company, a new and simplified version of the fluid catalytic cracking process has been placed in operation. Designed by Universal Oil Products Company, the new unit incorporates features intended to lower initial investment while providing all operating essentials necessary for the production of catalytically cracked gasoline.

BASIC operating principles of the new catalytic cracking unit at Detroit of Aurora Gasoline Company are those of other fluid type catalytic cracking units, but mechanical arrangement of equipment has been simplified by changing the relative position of reactor and regenerator, with consequent adjustment of vessel operating pressures to meet the head requirements for catalyst circulation.

The reactor is located immediately above the regenerator, with which it is combined in a single pressure vessel that forms a self-supported tower requiring little structure other than an elevated foundation, access platforms, and ladders. The whole assembly is roughly equivalent, structurally, to a large fractionating tower with the usual elevated support and platform system.

Preheated feed to the unit flows to a reactor feed line, where it is contacted with hot regenerated catalyst which enters the reactor feed line from the regen-

TABLE 1
Typical Results Fluid Catalytic Cracking Unit

YIELDS	BSD	Percent of Fresh Charge
Fresh charge stock (Ill.-Mich. gasoil)	4,030	100.0
Fuel gas	....	2.0 Wt. Percent
C_3 recovered	165	4.1 Vol. Percent
C_4 recovered	381	9.5 Vol. Percent
Gasoline	1,691	42.0 Vol. Percent
Heating oil	1,278	31.7 Vol. Percent
Fuel oil	657	16.3 Vol. Percent
Carbon	....	4.7 Wt. Percent

PROPERTIES OF PRODUCTS	Charge Stock	Gasoline	Heating Oil	Fuel Oil
Gravity, °API	29.9	60.6	31.1	26.6
Specific gravity at 60° F.	.8767	.7366	.8702	.8950
Octane Ratings:				
Motor Method, clear		78	....	
Motor method, +3.0cc TEL/gal.		87		
Res. method, clear		91		
Res. method, +3.0cc TEL/gal.		99		
Reid vapor pressure, pounds		6.7		
Flash point, °F.		.....	184	270
100 Ml Distillation:				
IBP, °F.		108	371	
10 percent		134	464	
30 percent		169	505	
50 percent		219	537	
70 percent		278	572	
90 percent		352	610	
End point, °F.		415	665	

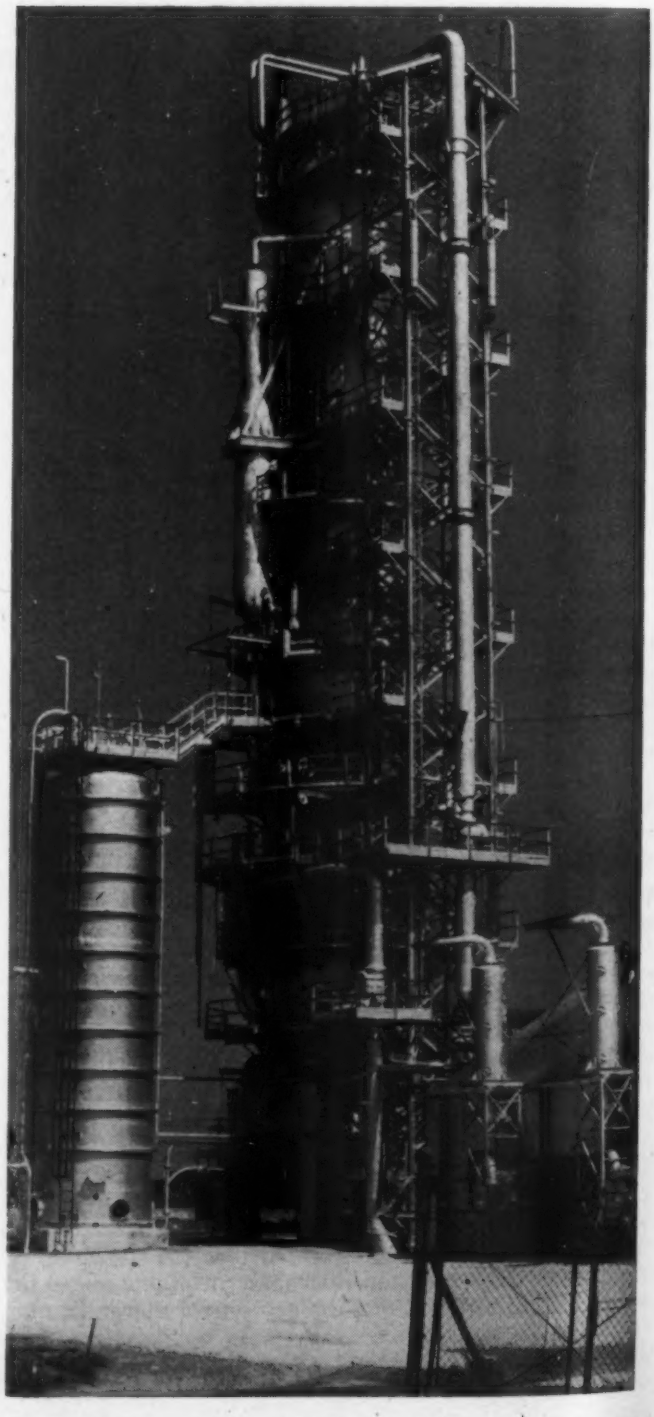


Photo at right shows Aurora Gasoline Company's new Fluid Catalytic Cracking Unit at Detroit, Michigan.

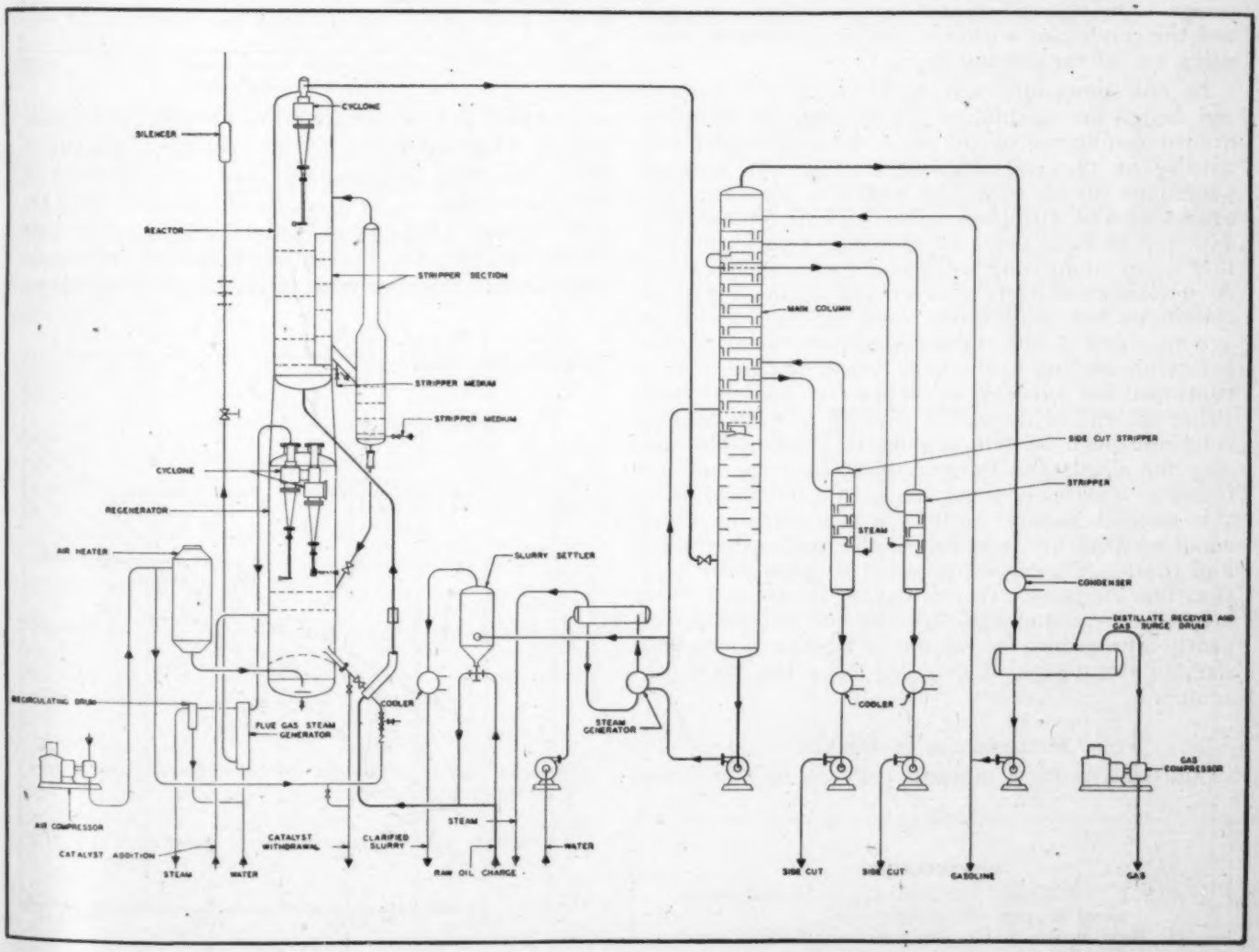
erator through a slide valve, under a combination of gravity and pressure-differential flow. The feed gasoil, heated by the catalyst to approximately cracking temperature and substantially vaporized, flows in mixture with this catalyst up the feed line to the reactor where it is held at cracking conditions while the desired conversion is effected and then leaves the reactor in vapor state, flowing through a cyclone separator which substantially removes entrained catalyst particles.

Reactor effluent vapors go to a fractionation system where gas, gasoline, cycle gasoils, and a bottoms slurry stream are produced as separate products. A slurry stream is recycled through the main fractionator tower lower section, as an intermediate reflux and catalyst washing stream, and all catalyst particles carried overhead with the reactor vapors are recovered here. Reflux heat is removed from this stream by means of a slurry system steam generator. Slurry is continuously removed to a settling vessel where it is concentrated so as to embody a minimum of the refractory cat cycle gasoil and is then returned to the reactor by means of a small stream of fresh feed diverted from the main charge to the reactor.

Spent catalyst is removed from the reactor through an internal stripper drawoff section to an external stripper where it is contacted with stripping vapors before flowing down to the regenerator through a slide valve. Carbon deposit on the catalyst is removed by combustion with air in the regenerator, and the regenerated catalyst flows to contact fresh feed vapors, completing the catalyst system operational cycle.

Flue gases leave the regenerator through cyclone separators for catalyst removal, through a flue gas steam generator for waste heat recovery, and are released to atmosphere through a back pressure control valve and a noise silencer.

Yields and inspections of products from a typical operation of the unit are shown in Table 1.



Flow diagram of Aurora Gasoline Company's new Fluid Catalytic Cracking Unit, designed, engineered and licensed by Universal Oil Products Co.

Pipestill Coil Design

A Method of Calculation for the Conditions Within the Tubes of Pipestill Heaters

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A METHOD is presented for the calculation of the complete conditions—the temperatures, pressures, percents vaporized, etc.—of the fluids flowing within the tubes of pipe still heaters. Integral and differential values for the fluid conditions along the coil are obtained alternately in a trial and error procedure. The calculations can be performed rapidly and the results can be made exact within the accuracy of the date used. Two illustrative examples of the use of the method are included.

AT THE present time the laws governing the radiation of heat in furnaces are well understood. The work of Shack,[5] Hottel and co-workers,[2] Lobo and Evans,[3] and others has made possible the accurate design of the radiant sections of pipestill heaters. However, these design calculations are for the combustion space outside the tubes; and the tubes themselves are usually considered to be simply a heat-absorbing plane. The other half of the complete design of a pipestill heater involves the coil itself and the conditions within it, the temperatures, pressures, etc. of the flowing fluid.

In one procedure sometimes used for pipestill coil design the calculation begins with the complete known conditions of the fluid at some one point, usually at the coil inlet or outlet. The average conditions for an adjoining length of pipe are then estimated, and with these values and the fundamental data the finite changes in pressure, heat input, etc. that occur along this section of coil are calculated. A check is then made to see if the assumed average conditions are sufficiently close to the calculated average, and if not the computations are repeated before proceeding to the next length of pipe. This is continued for succeeding sections of the coil until either the end of the coil is reached or some desired condition such as temperature is attained. In this way the changes in the variables along the coil are found as a series of finite steps. In a modification of this method Nelson[4] outlines a procedure in which small temperature increases of the fluid are assumed and the lengths of coil required to give these temperature increases are calculated. In general these step-wise procedures are tedious and uncertain. Recently a procedure for the use of laboratory cracking data in the design of cracking coils has been presented.[1]

Mathematics of Method

Mathematically a pipestill coil can be considered to be a path of flow along which a number of variables change. These variables are the conditions of the fluid—the temperature, pressure, etc.—and are designated by the general terms *A, B, C . . . E*. The position along the path of flow is designated by the symbol *L*. Only part of the variables *(A, B)* can be considered to be independent with the remainder *(C . . . E)* being dependent.

NOMENCLATURE

- *A, B, C . . . E* General variables. Conditions that change along the path of the fluid.
- *H* Heat input variable. Btu's per pound added to the fluid. Based on liquid at 465° F. in the examples.
- *L* Position along the path of the fluid. Measured as pressure drop equivalent length in feet for the examples.
- *P* Pressure in pounds per square inch absolute (psia).
- *T* Temperature in ° F.
- *V* Liquid volume percent of the fluid that is vaporized.

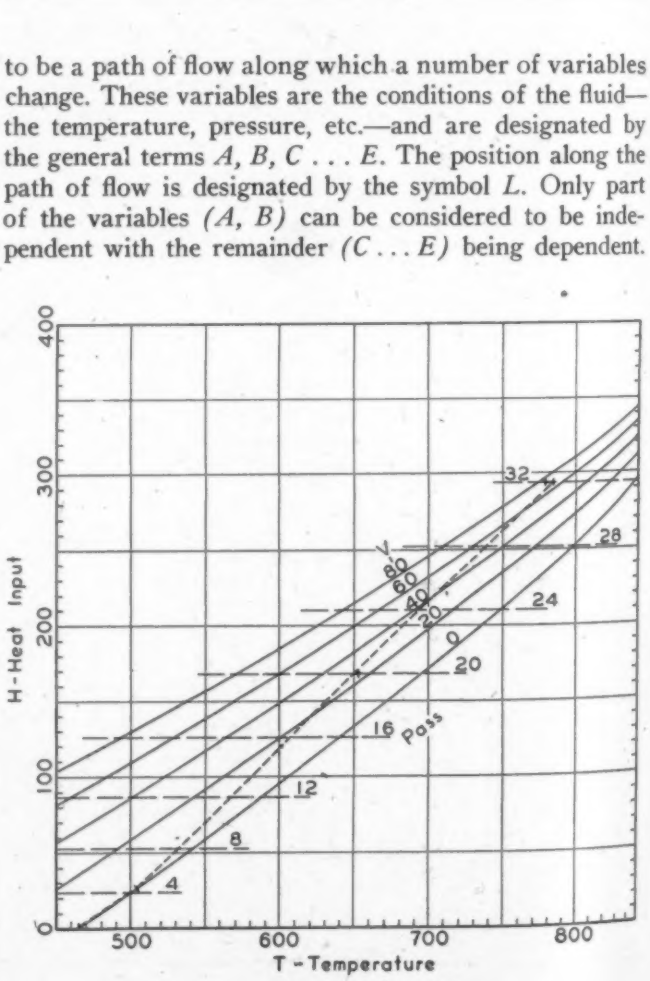

FIGURE 1

The thermal properties of the crude oil. Heat input in Btu per pound vs. temperature in °F. for constant liquid volume percents vaporized (H vs. T at constant V). The heat input is zero for liquid at 465° F.

Dashed horizontal lines—Known heat input at pass numbers given for Example I.

Heavy dashed line—Path of fluid in coil for Example I.

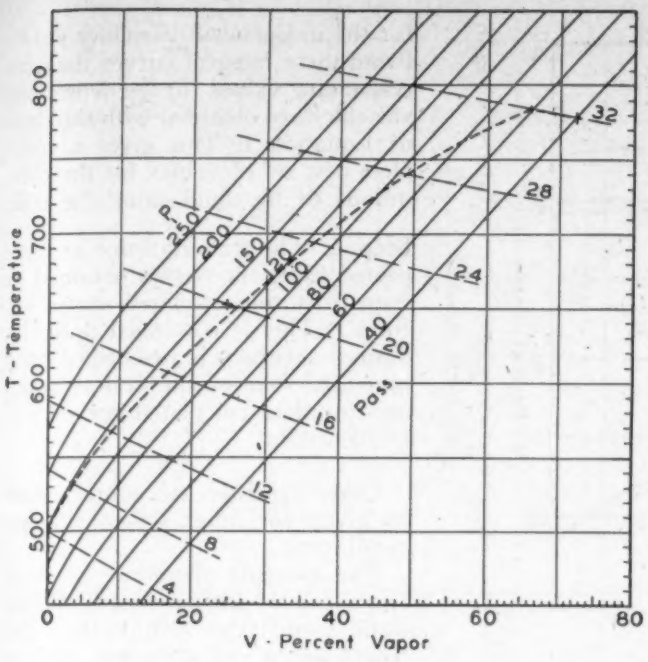

FIGURE 2

The vaporization properties of the crude oil. Temperature in °F. vs. liquid volume percent vaporized at constant pressures in psia (T vs. V at Constant P).

Dashed horizontal lines—Lines of known constant heat input for pass numbers given for Example I.

Heavy dashed line—Path of fluid in coil for Example I.

The number of independent variables is the minimum required to define completely the conditions of the fluid. Thus if the pressure and heat input to a known fluid were fixed then the temperature and percent vaporized would also be fixed. In this case P and H would be the independent variables and T and V the dependent ones.

In order to solve for the fluid conditions along a length of coil three types of data are required as follows:

First.

The complete properties of the fluid must be known; i.e., values of dependent variables must be known as functions of the independent variables. These data can be expressed as

$$C = f_1(A, B) \qquad (1C)$$
$$E = f_2(A, B) \qquad (1E)$$

where A and B are independent and $C \ldots E$ are dependent. Thus if T and V are considered to be dependent functions of H. and P, then some way of determining T and V at values of H and P must be available.

Second.

The rates of change of the independent variables along the coil *(dA/dL, dB/dL,* etc.) must be known as functions of the fluid conditions and the position along the coil. This can be expressed as

$$dA/dL = f_1(L, A, B, C \ldots E) \qquad (2A)$$
$$dB/dL = f_2(L, A, B, C \ldots E) \qquad (2B)$$
etc.

Thus the pressure drop per length of pipe may be known as a function of the pressure and the percent vaporized of the fluid, i.e.,

$$dP/dL = f_3(P, V) \qquad (2P)$$

In general the variables picked to be independent will be the ones for which these data are most readily available.

Third.

Enough information about the coil must be known so that only a single solution is possible. In general for most calculations the fluid itself, the amount of fluid and the coil diameter, are known. In addition to these, one value for each of the independent variables, or the equivalent, and one additional condition must be known. This additional condition may be a temperature to be reached, a total heat input, a length of coil, etc., depending on the design requirements.

The general method for obtaining a complete solution for the coil from these data consists of determining differential and integral curves for the variables alternately in a trial and error procedure. Thus a consistent set of curves of $A, B, C \ldots E$ vs. L can be estimated and the resulting differential curves of dA/dL vs. L, dB/dL vs. L, etc., can be obtained with the data of Equation 2. These differential curves can then be integrated to give new and more accurate curves for the variables along the coil. If in such a trial the estimated and calculated sets of integral curves are the same then the correct conditions of the fluid along the coil have been found. The integration of the differential curves can be expressed as

$$A_2 = \int_1^2 (dA/dL)dL + A_1 \qquad (3A)$$

$$B_2 = \int_1^2 (dB/dL)dL + B_1 \qquad (3B)$$

Subscript 1 indicates the position along the coil at which a value for the variable is known, and Subscript 2 indicates the general position, i.e., any point along the coil. In the actual calculations the integral curves are most conveniently obtained by determining the areas under succeeding sections of the differential curves with a planimeter.

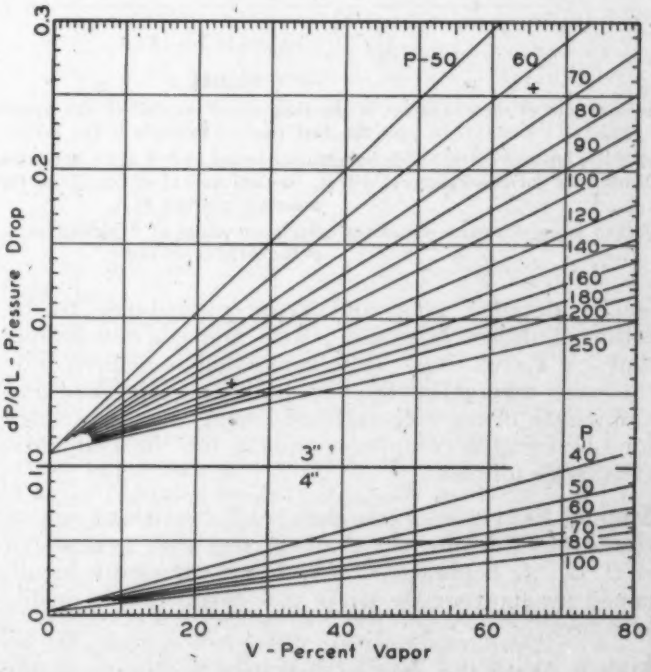

FIGURE 3

Pressure drop data for 3" heater coil and 4" transfer line for a flow of 3000 BPD of crude oil. Pressure drop in pounds per square inch per foot length of pipe plotted vs. the liquid volume percent vaporized for constant pressures in psia. (dP/dL vs. V at constant P).

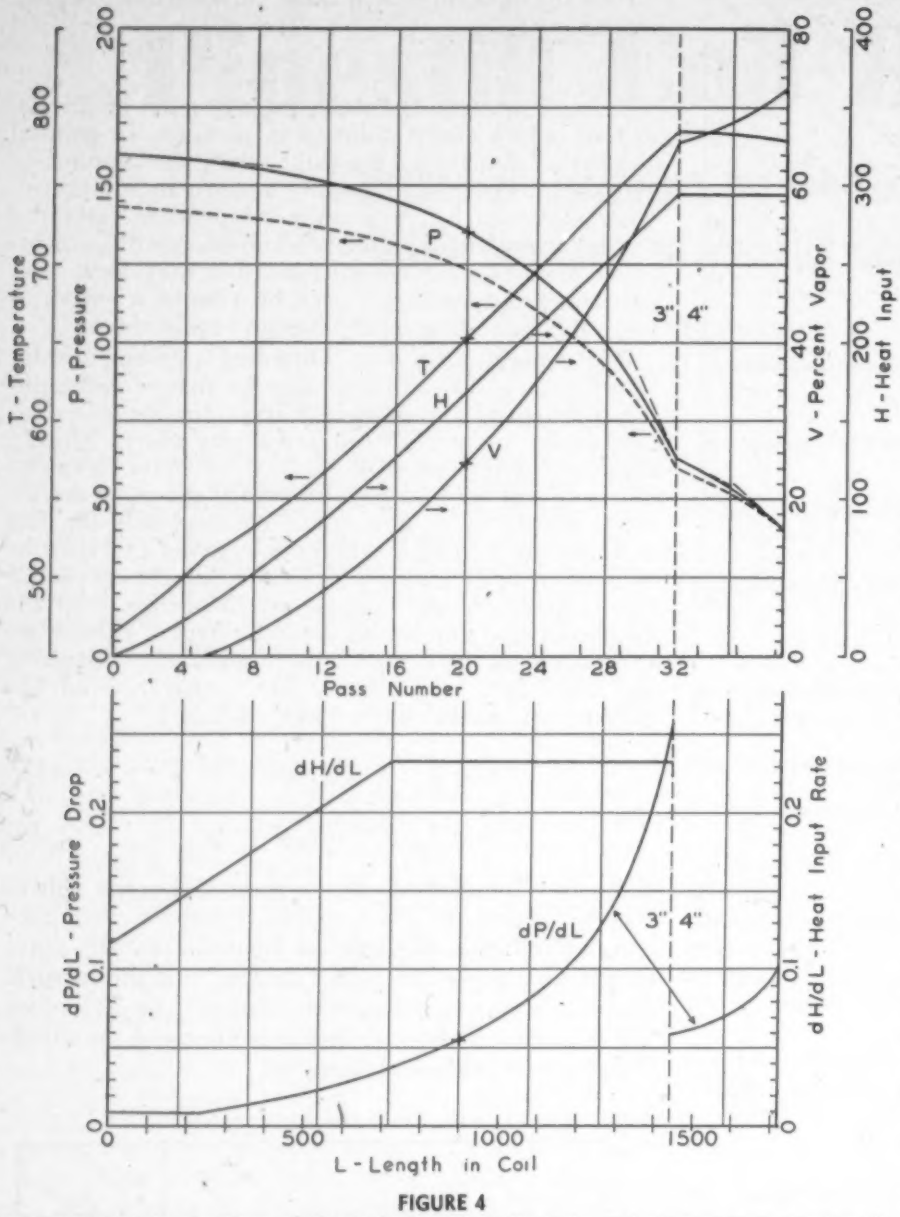

FIGURE 4

General plot of the conditions of the fluid along the coil vs. the equivalent pressure drop length for the first trial of Example I. See text.

Solid line integral curves—Original assumed values of P, T and V and known values of H plotted vs. L. Differential curves—Values of dH/dL (known) and of dP/dL (from Figure III for the conditions assumed) plotted vs. L.

Dashed integral curves—Resultant calculated values of P plotted vs. L. Obtained by integration of the differential curve.

The detailed trial and error procedures to be followed differ, of course, with the coil conditions that are known and the solution that is desired. For the case where the flow of fluid and the diameter and length of the coil are fixed a suggested procedure for obtaining a complete solution for the coil variables is as follows:

Step 1. Estimate a complete and consistent set of conditions for the fluid along the coil (values of *A B, C . . . E* plotted vs. *L)*. These values can be obtained by approximate trials and should be reasonably accurate.

Step 2. With the data of Equation 2 plot vs. *L* the differential values of the independent variables *(dA/dL, dB/dL,* etc.) for the coil conditions of Step 1.

Step 3. Integrate the differential curves of Step 2 (Equation 3) to obtain new and more accurate curves for the independent variables vs. *L*. From these integral curves the corresponding values for the dependent variables are obtained with the data of Equation 1. This gives a complete new set of values for the conditions of the fluid along the coil.

Step 4. The calculations are repeated using the curves obtained in Step 3 as the estimated curves of Step 1. This is continued until the desired accuracy is reached. At the true final solution the first assumed and resultant calculated curves will be identical.

Other similar procedures could be given for other sets of known conditions.

The example procedure given is for a coil of known length. When some condition other than the length of the coil is known, such as a temperature to be reached, then frequently it is possible to assume a coil longer than is necessary, and then to find the length required to obtain the given condition. In these calculations it is necessary to define what is meant by the "length" of the coil. Thus for one pass the actual tube length is 30 feet, the heated length is 29 feet, the fluid travel including header is 31 feet, and the equivalent length of straight pipe for pressure drop calculations is 45 feet. Either the heated length or the pressure drop equivalent length should be used as a basis for *L* depending on whether heat input or pressure drop is the more important variable. The same basis for the coil length, of course, is used for all of the variables. Ordinarily it is more convenient to simply consider that the variables such as pressure, heat input, etc., give a continuous smooth curve over the length of the coil rather than to show discontinuities at the ends of the tubes.

In trial and error calculations certain time-saving devices can frequently be used to advantage. Thus the closer the first assumed conditions are to the final true conditions the fewer trials will be required. The original assumed values of Step 1 for the conditions along the coil need not be pure guesses but rather can be based on quick approximate trials. Sometimes average conditions for the entire coil can be assumed and the resultant overall change of the variables determined. Or when a variable is not sensitive to the values of the other variables average conditions along the coil can be assumed and the curve of the variable determined by a quick integration. Thus in the radiant heating of a cold stream the heat input is comparatively independent of the conditions of the fluid so that for a known radiating temperature the heat input curve can be determined fairly accurately without knowing any of the conditions along the coil

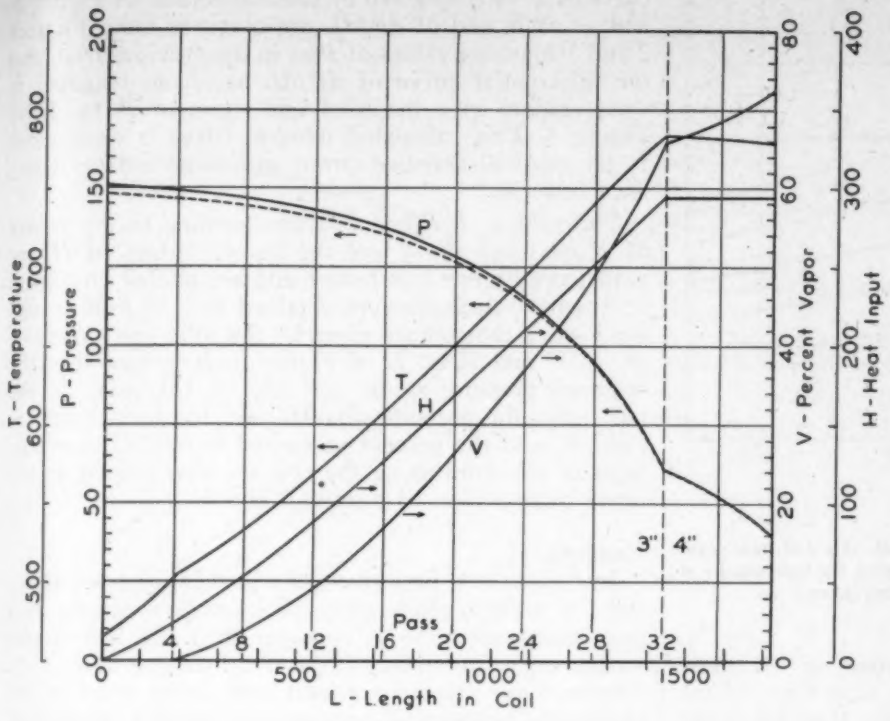

FIGURE 5

General plot of the conditions of the fluid along the coil plotted vs. the equivalent pressure drop length as obtained in the final trial of Example I. Values of H, P, T and V plotted vs. L. Dashed line curve—Values of P vs. L assumed at the beginning of the final trial.

except an average temperature. Various other useful approximate trials will become obvious to someone performing the calculations. With reasonable care in obtaining the first estimates only two complete trials of the type described will be required for any ordinary accuracy.

Frequently it is possible to obtain the approximate slope of a curve at a point even though the actual values of the variables at the point are not known, and this aids in assuming the integral curve. Often time can be saved by "guessing which way the cat will jump," i.e., by estimating from a trial a set of integral curves that are closer to the true curves than are the results of the trial. Various other time-saving devices could be given and some of these are illustrated in the two example calculations that follow.

Example I

A coil in the radiant section of a pipestill heater consists of 32 passes of 3-inch (inside diameter) pipe 30 feet long arranged in a single row. Because of the return bends each of these passes may be considered to cause a pressure drop equal to that of 45 feet of straight pipe. The entire coil, then, has an equivalent pressure drop length of 1440 feet. This coil connects into a 4-inch transfer line that discharges into a distillation tower, and this line has an equivalent pressure drop length of 280 feet. From the shape of the combustion chamber and the location of the burners it can be estimated that the heat input rate (dH/dL) is constant for the last half of the coil (Passes 16 to 32), and that this rate decreases as a straight line from Pass 16 to a value one half as great at the coil inlet (Pass 0). A heat input rate curve of this shape is shown by the plot of dH/dL vs. L of Figure 4.

The feed to this coil is to be 3000 barrels per day of a 35°-API crude oil at 465° F. In order to obtain the desired topping it is necessary that this crude be 72.5 percent vaporized at the discharge into the distillation tower. The tower pressure is to be 40 psia. It is desired to know the condition of the fluid along this coil and particularly the pressure required, at the coil inlet and the pressure temperature and percent vaporized at the coil outlet.

The fundamental data required for the calculation are given on Figures 1, 2 and 3. The thermal properties of the crude are given on Figure 1 which is a plot of heat input above liquid at 465°F. vs. temperature in °F. for constant liquid volume percents vaporized *(H* vs. *T* at constant *V)*. The vaporization properties of the crude are given by the equilibrium flash curves at various pressures *(T* vs. *V* at constant *P)* of Figure 2. The pressure drop in pounds per square inch per foot length of coil for both the 3-inch heater coil and the 4-inch transfer line is given on Figure 3 as a function of the pressure and the liquid volume percent vaporized (dP/dL vs. V at constant P) for a flow of 3000 barrels per day of crude oil.

From Figure 2 it is seen that for 72.5 percent vaporized at 40 psia the temperature required is 779° F., and from Figure 1 the heat input required to reach this temperature is 294 Btu per pound. The heat input curve of the shape described that gives the required 294 Btu per pound total input is given by the plot of dH/dL vs. L in the lower section of Figure 4. This curve gives the heat input to a pound of crude in passing along one foot of the coil. The area under this curve, of course, represents total heat input, and the integration in sections gives the integral plot of H vs. L of Figure 4. For convenience the values of H at every fourth pass number (0, 4, 8 . . . 32) as given by this integral curve are marked off by dashed horizontal lines on Figure 1. And values of T and V corresponding to these heat inputs are replotted on Figure 2 to give the dashed lines that slope to the right. These lines of constant heat input are labeled with the corresponding pass number, and the fluid conditions at the pass numbers given lie somewhere on these lines.

With the heat input along the coil known, one additional property will completely define the condition of the fluid. Because of the pressure drop data available (Figure 3) pressure is selected as this independent variable. However, the pressure drop depends on the percent vaporized, and so V is taken as a dependent variable. Temperature does not need to be included in the calculation, but the coil temperatures are desired and so plots of T vs. L are given.

The first step in the trial and error procedures is to estimate the conditions of the fluid along the entire pipe, and this is done with quick, approximate trials. Average conditions for the transfer line are assumed and, with Figure 3, a pressure drop of 24 psia is obtained. Then the approximate pressure at the coil outlet is $40 + 24 = 64$ psia. Similar rough calculations are made for the coil, and a coil inlet pressure

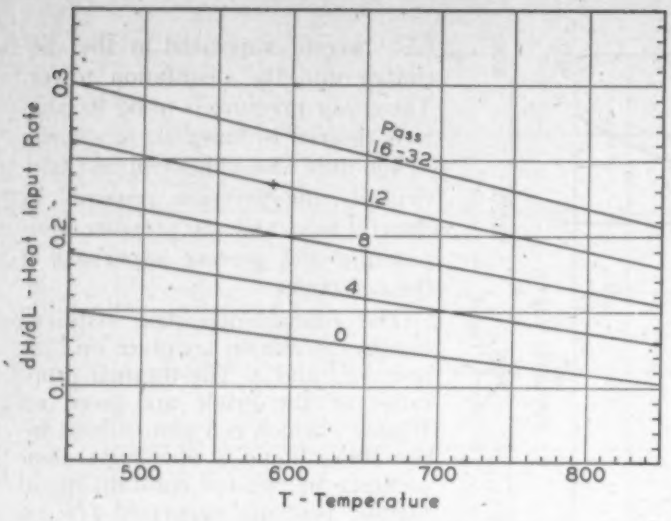

FIGURE 6

Heat input rates for Example II. Values of dH/dL (Btu's of heat input per pound of crude per foot length of coil) plotted vs. the temperature of the fluid in °F. at the pass numbers given.

of 160 psia is selected as being reasonable. At these pressures values of V and of dP/dL (the slope of the pressure curve) can be found. Thus for $P = 64$ at the coil outlet $V = 65.7$ as read from the total heat input line (Pass 32) of Figure 2. And at these values of P and V the value of dP/dL is 0.256 as read from Figure 3. A line of this slope is drawn through $P = 64$ at the coil outlet as shown on Figure 4, and slope lines similarly obtained are drawn at the coil inlet and the transfer line inlet and outlet. With the aid of the points and tangents obtained in this manner the solid line curve of P vs. L of Figure 4 is drawn. From the value of P given by this curve, the known values of H and the data of Figure 2, the values of T and V along the coil can be found. Thus the estimated value of P at Pass 20 is 136 psia, and from the corresponding known heat input line of Figure 2 the values $T = 653°$ F. and $V = 24.8$ percent vaporized can be read. These values and others obtained similarly give the plots of T and V vs. L of Figure 4. Then the solid line integral curves of Figure 4 give a complete and consistent set of estimated conditions for the fluid along the coil.

From the values of P and V of these curves the corresponding values of dP/dL can be read from Figure 3, and the points obtained are plotted to give the differential curve of dP/dL vs. L in the lower section of Figure 4. Thus $P = 136$ and $V = 24.8$ for Pass 20, and for these values Figure 3 gives $dP/dL = 0.056$ as plotted on Figure 4. The area under this plot of dP/dL vs. L, of course, represents total pressure drop (Equation 3). This curve is integrated in sections with a planimeter to give the new calculated integral curve of P vs. L shown by the dashed line of Figure 4. It is seen that pressures of 60.0 psia at the coil outlet and of 143.5 psia at the coil inlet are obtained. Evidently the assumed and calculated curves of P vs. L of Figure 4 are too far apart so that a new trial is required.

It is next necessary to estimate as closely as possible the true curve of P vs. L from the results obtained in the first trial (Figure 4). Assumed values of P that are too high give values of dP/dL that are too low and, consequently, pressure drops that are too low. Then the true curve of P vs. L lies somewhere between the two curves of Figure 4. For this second trial the assumed curve of P vs. L is given by the dashed line of Figure 5. Values of V and of dP/dL are obtained from Figures 2 and 3 for these values of P as in the previous trial, and the differential curve of dP/dL vs. L so obtained is integrated to give the solid line curve of P vs. L of Figure 5. This calculated integral curve is quite close to the original assumed curve and so no further trials need be made.

The values of T and V corresponding to the values of P obtained above and the known values of H are read from Figure 2 as before and are plotted on Figure 5. Then the final answers obtained for the fluid conditions along the coil are given by the solid line curves of H, P, V and T vs. L of Figure 5. It is seen that the required pressure at the coil inlet is 151 psia. At the coil outlet the pressure of 60.6 psia, the temperature is 784° F, and the percent vaporized is 66.0. The conditions of the fluid along the coil are also plotted as the heavy dashed lines of Figures 1 and 2.

Example II

In Example I, just given, the heat input rates along the coil were considered to be known constants. But it is more accurate to consider that the heat input varies as a function of the fluid temperature. On Figure 6 are given estimated heat input rates at the maximum bridgewall temperature for the furnace of Example I. The rates at various pass numbers are shown as functions of the fluid temperatures. As in Example I the charge to this coil is to be 3000 barrels per day of crude at 465° F., and the tower pressure is to be 40 psia. It is desired to know the conditions along the coil at this maximum firing rate and particularly the pressure at the coil inlet, the total heat input, the temperature at the coil outlet, and the percent vaporized at the tower inlet.

For this calculation two variables are required to define completely the condition of the fluid, and because of the pressure drop data and heat input rates available (Figures 3 and 6) H and P are selected as these independent variables. Also the values of dH/dL and dP/dL vary with the temperature and the percent vaporized, and so T and V are taken as dependent variables. The first step of the calculation is to obtain a complete and consistent set of estimated values for the conditions of the fluid along the coil, and the values chosen are given by the solid line curves of H, P, T and V vs. L of Figure 7. These values were obtained from the solution of Example I by a careful use of ratios. It is seen that the assumed total heat input is 315 Btu per pound, and that the assumed pressures are 160 psia at the coil inlet and 62 psia at the coil outlet.

From these estimated curves and the data of Figures 3 and 6 values for the differential curves of dH/dL and dP/dL vs. L are obtained as in Example I, and these are plotted in the lower section of Figure 7. Thus the temperature estimated for the end of Pass 12 is 587° F., and from Figure 6 the corresponding heat input rate (dH/dL) is 0.234 Btu per pound of crude per foot length of coil. These values are marked off on the curves. The two differential curves of dH/dL and dP/dL vs. L are next integrated in sections with a planimeter to give new calculated curves of H and P vs. L as shown by the dashed line curves of Figure 7. Evidently the assumed and calculated curves of H and P vs. L are sufficiently close so that no further trials need be made. Values of T and V corresponding to calculated values of H and P are obtained from Figures 1 and 2 and are

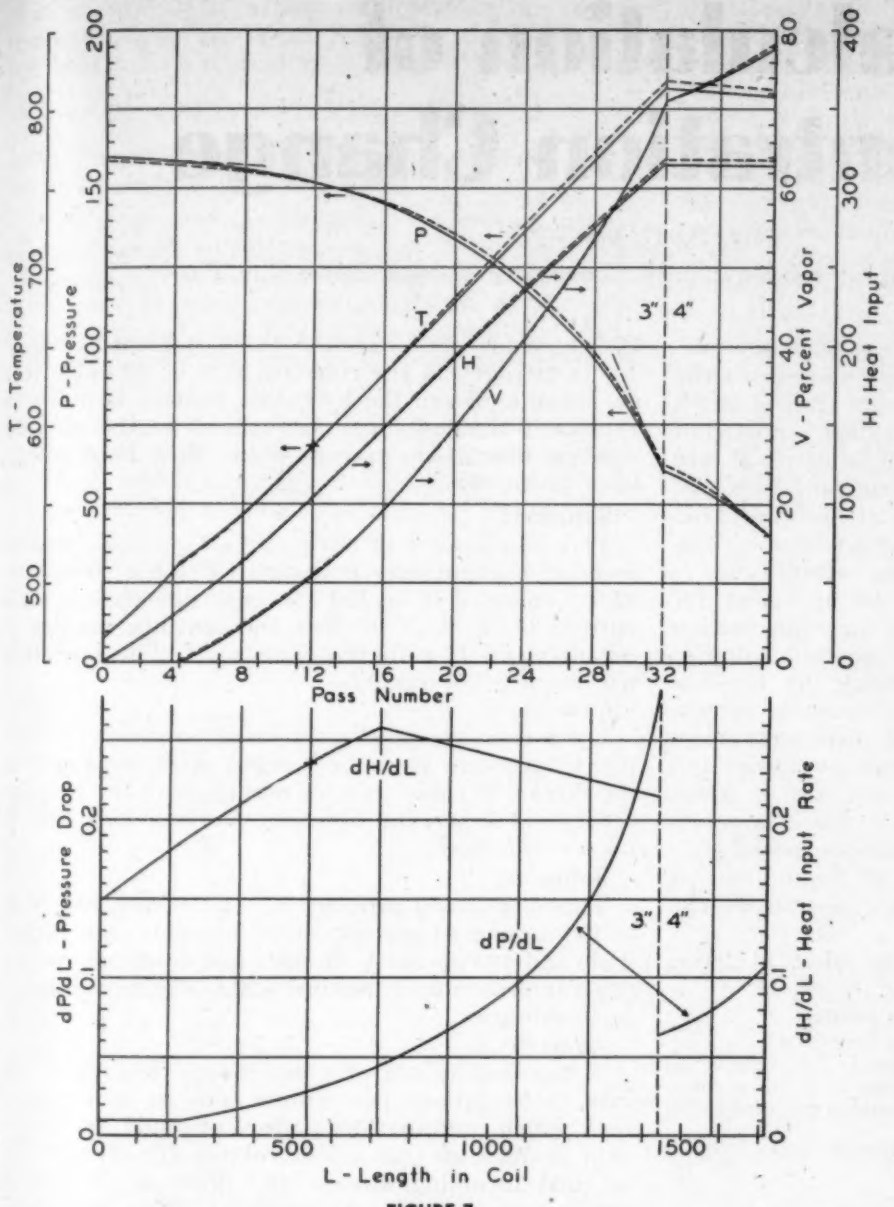

FIGURE 7

General plot of the conditions of the fluid along the coil vs. the equivalent pressure drop length for Example II. See text.

Solid line integral curves—Original assumed values of H, P, T and V plotted vs. L. Differential curves—Values of dP/dL and of dH/dL plotted vs. L. Obtained from Figures III and VI for the assumed conditions.

Dashed line integral curves—Final calculated values of H, P, T, and V plotted vs L. Obtained by the integration of the differential curves.

plotted as dashed lines on Figure 7. Then the complete final solution for the condition of the fluid along the coil at the maximum firing rate of the furnace are given by the dashed line curves of Figure 7. It is seen that the total heat input is 318 Btu per pound of crude, and that the pressure is 158.4 psia at the coil inlet and 62.8 psia at the coil outlet. The temperature is 817° at the coil outlet and 812° at the transfer line outlet. The percent vaporized is 71.0 percent at the coil outlet and 78.5 percent at the transfer line outlet.

Advantages

The method given here for the pipestill coil calculations is believed to have certain advantages, and these are summarized as follows:

1) The method is completely flexible. Problems of any complexity and with any combination of variables can be calculated provided the required data are available. Thus two independent variables were handled in Example II as easily as one in Example I, and more could have been included.

2) It is not necessary to know the complete fluid conditions at any one point along the coil as a starting point for the calculations. Thus in Example II the pressure at the coil inlet and the heat input at the transfer line outlet were not known, and yet the solution was easily obtained. In any stepwise procedure such a starting point is required.

3) No averaged values for a length of coil need be used. The increments are infinitesimal rather than finite so that the calculus is exact. The answer obtained can be made as accurate as the fundamental data used. In extreme cases the discontinuities at the ends of the individual tubes can be included if such accuracy is desired.

4) Once the necessary fundamental data have been assembled the calculations are quite rapid. Thus either Example I or II could be worked out within an hour by someone familiar with the method, provided, of course, that Figures 1, 2, 3 and 6 were already prepared.

The present calculations have been primarily concerned with the coils of pipestill heaters. But the fundamental method of alternating differential and integral curves in a trial and error procedure is believed to have other applications. Thus a simple example would be the calculation of the expansion of gas along a pipe. A more complicated application would concern the pressure, temperature and composition changes in the passage of reacting gases through a catalyst bed. Of particular interest is the calculation of the variables along a packed distillation or absorption column. In general the requirements for the use of the general method are that the changes can be considered to occur along a line and that data of the three types listed can be made available.

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Calculation of Concentration Change

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A TYPE of problem common in pilot plant practice and recurrent also in large scale operations is the calculation of concentration of stream from a batch mixing operation. The idealized system consists of a completely mixed constant volume of material into which is charged a stream at a constant rate and from which a stream is withdrawn at the same rate. Blending, dilution, concentration by addition of concentrate, and purging are operations of this tvpe.

In general, equations must be set up either for 1) calculating the necessary rate of incoming stream that will accomplish the desired concentration change in a definite time; or 2) for calculating the duration of the operation at a given rate of incoming stream that will accomplish the desired concentration change, or 3) for determining necessary initial and final concentrations for a given rate and a given duration time of operation. In every case it is necessary to assume complete mixing, unless special data are at hand, and it is necessary to set up and solve a separate differential equation. These operations can be divided into two cases:

Case I: Incoming stream contains no solute. (Diluting and purging operations.)

Case II: Incoming stream contains solute.

For Case I: Let C = concentration at time, t.
C_1 = initial concentration
C_2 = final concentration
} based on volume
V = volume of material being changed in concentration
R = flow rate of streams (volume/time)

then, by solute balance,

$$-V\,dC = R\,C\,dt$$

$$\int_{C_1}^{C_2} -\frac{dC}{C} = \frac{R}{V}\int_0^t dt$$

$$t = \frac{V}{R}\ \ln\ \frac{C_1}{C_2}$$

For Case II: If the incoming stream has a concentration, C_1, then, by solute balance:

$$C_1 R\,dt - C\,R\,dt = V\,dC$$

$$\frac{Rt}{V} = \int_{C_1}^{C_2} \frac{dC}{C_1 - C} = -\ln\ \frac{C_1 - C_2}{C_1 - C_1} = -\ln\ \frac{C_2 - C_1}{C_1 - C_1}$$

Note that the quantity $\frac{C_2 - C_1}{C_1 - C_1}$ is the fraction of the total possible concentration change, $(C_1 - C_1)$, that remains to occur after time, t.

Since the two cases have identical mathematical form, a graphical method is indicated which would allow quick solution for any of the five variables. Figure 1 is a nomograph constructed for this purpose. The following examples should make its use clear.

Example 1:

A 1000-cubic-foot tank containing 75 mol. percent hydrogen and 25 mol. percent carbon dioxide is to have the hydrogen content reduced to 1 mol. percent by bleeding in nitrogen at the constant rate of 30 cubic feet per minute. When the hydrogen content is down to 1 percent the tank may be opened to the air and welding operations may proceed. How long will it take to do this?

Solution:

This is a Case I problem. $\%C_2/C_1 = 1.33$ percent $= 1/75$. Volume over flow rate $(V/R) = 1000(30 = 33.3$. Connect 1.33 on the concentration change scale with 33.33 on the V/R scale and continue the line to its intersection with the time scale. The operation will require 140 minutes.

Example 2:

A 300-cubic-foot tank containing propane at atmospheric pressure is to be purged with inert gas at the rate of 30 cubic feet per minute until the propane content is 1 percent by volume. How long will it take to do this?

Solution:

This is a Case I problem. $C_2/C_1 = 1$ percent; $V/R = 100$. Connect 1 percent on the concentration change scale and 100 on the V/R scale and continue the line to its intersection of the time scale. The time required is 46 minutes.

Example 3:

A low-boiling cut of petroleum is flowing at the rate of 50 gallons per minute into an accumulator tank which contains 2500 gallons of liquid. A changeover is made so that a less volatile cut replaces the original incoming stream and flows at 50 gallons per minute into the accumulator. It is desired to sample the effluent stream when the concentration change is 90 percent complete. (i.e., when the fraction of the total possible concentration change remaining to occur is 10 percent.) How long after the new stream is introduced shall the sample be taken?

Solution:

This is a Case II problem. $V/R = 50$. Connect 10 percent on the concentration change scale with 50 on the V/R scale and continue the line to its intersection with the time scale. From the line drawn on the nomograph it can be seen that 116 minutes should elapse before the sample is taken.

Example 4:

A warehouse room, 50 x 30 x 20 feet is filled with substantially dry gas of the following composition:

CO_2	8 percent
CO	3 percent
O_2	2 percent
N_2	87 percent

A fan of estimated capacity 1000 cubic feet per minute is installed to blow air into the room. How long should it take to make the atmosphere fit for workmen to enter?

Solution:

With respect to the removal of CO this is a Case I

PERCENTAGE OF CONCENTRATION CHANGE REMAINING TO OCCUR (CASE 2)

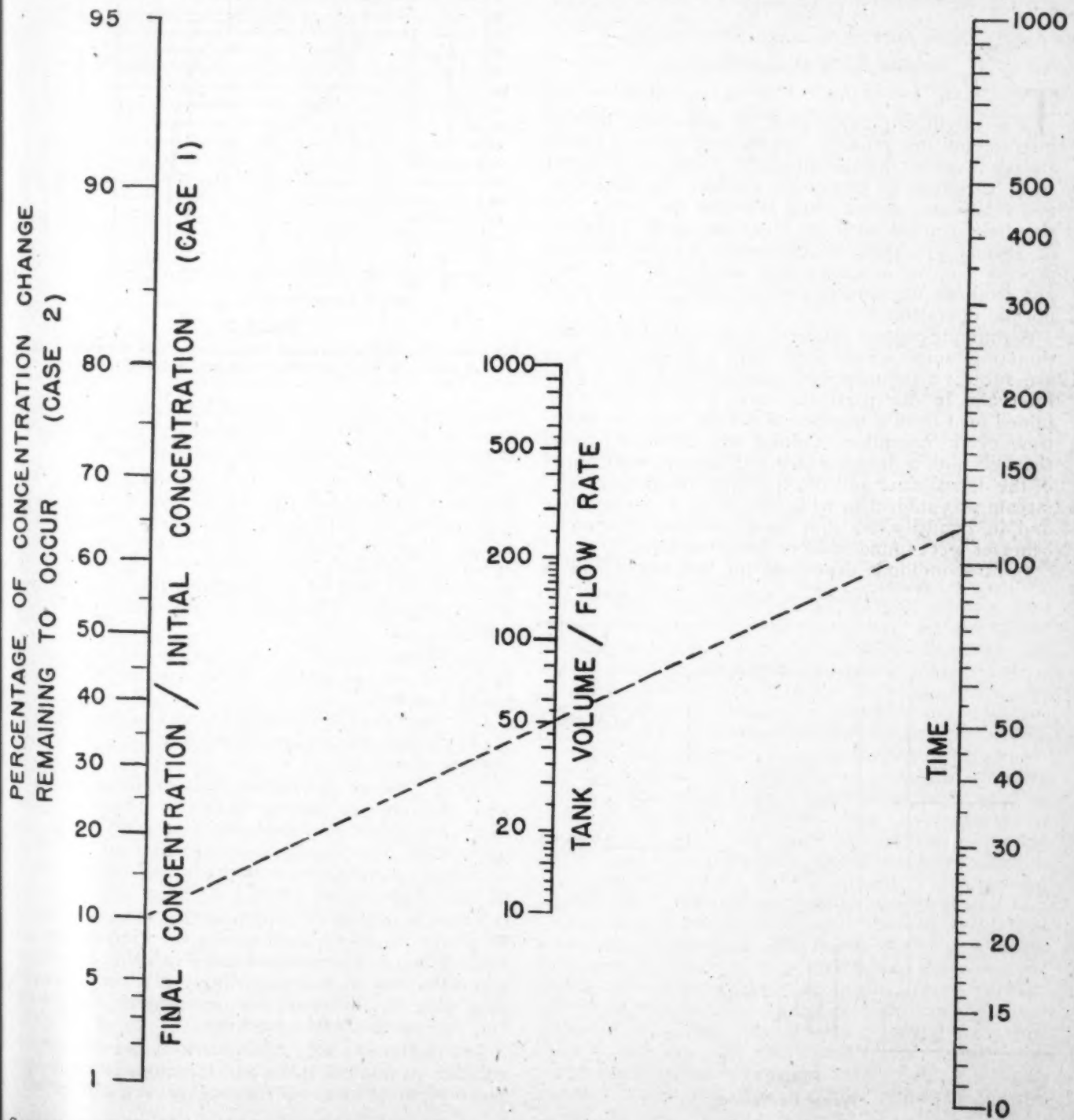
problem and with respect to increasing the oxygen content it is a Case II problem. First the CO, assuming that a CO content of 0.1 percent is harmless: $\% \frac{C_2}{C_1} = \frac{0.1}{3.0} \times 100 = 3.33$; $V/R = 50 \times 30 \times 20/1000 = 30$. From the nomograph the time required is estimated as above to be 103 minutes.

With respect to the oxygen concentration, assuming that the air will be satisfactory when the change of oxygen concentration from 2 percent to 21 percent is 95 percent complete—or 5 percent of the total possible concentration change remains to occur; $V/R = 30$. Solution by the nomograph gives 90 minutes.

It is of interest in this problem to find also the time required for reducing the CO_2 content to a safe level which is assumed to be 1 percent. This is a Case I problem. $\%C_2/C_1 = 12.5$; $V/R = 30$. From the nomograph the time is estimated to be 63 minutes. The controlling factor is, therefore, the carbon monoxide.

In any actual purging operation there will be a certain amount of displacement because mixing is not perfect. This will result in a shorter time being required than is calculated. The time estimated from the nomograph will, therefore, be the maximum time required and will be a safe figure for dilutions such as the examples given. If it is desired to dilute a gas accurately to a certain concentration in this manner precautions should be taken to have the mixing as nearly complete as possible. This means that the flow rate of the diluting stream should be small in comparison with the tank volume and that mixing devices should be used.

It should be seen that the concentrations are based on volume and have the same units. R has the same volume unit as V and the same time unit as t.



Notes On—

Control of Light Hydrocarbon Fractionators Subject to Variations in Feed Composition and Quantity

E. D. MATTIX
Cities Service Refining Corporation
Lake Charles, Louisiana

THE intelligent application of automatic control instruments to refinery continuous process units always involves the special study of each installation since variation in processes, product specifications, and equipment design often preclude the use of "off the shelf" control schemes. More specifically, unusual or special operating requirements may necessitate process control arrangements capable of functions not required for similar process units having more normal operation.

A difficult control problem is encountered in fractionating units where feed rates and compositions are subject to considerable variation in short time intervals. In one particular case a debutanizer obtained feed from a number of coking units on short-time cyclic operation. Coking unit effluent passed through both a deheptanizer and depropanizer ahead of the debutanizer and the resulting debutanizer feed stream was subject to wide variations in composition and in quantity, so that usual control instrument schemes were found to be entirely inadequate.

Control methods developed for this tower will be described, but as a preliminary—it deems desirable to consider some of the factors affecting control applications to light hydrocarbon processing units.

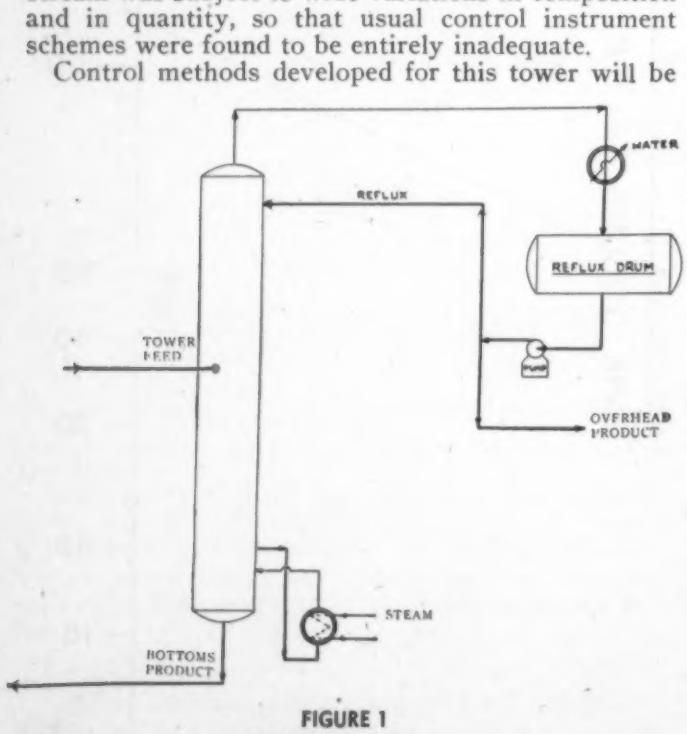


FIGURE 1
Typical Fractionator

CASE	I	II	III
OVERHEAD PRODUCT, % OF FEED	50.	50.99	49.01
MOL. % BUTANE IN BTM. PRODUCT	0.25	0.06	2.02
MOL. % PENTANE IN O.H PRODUCT	0.25	2.0	0.08

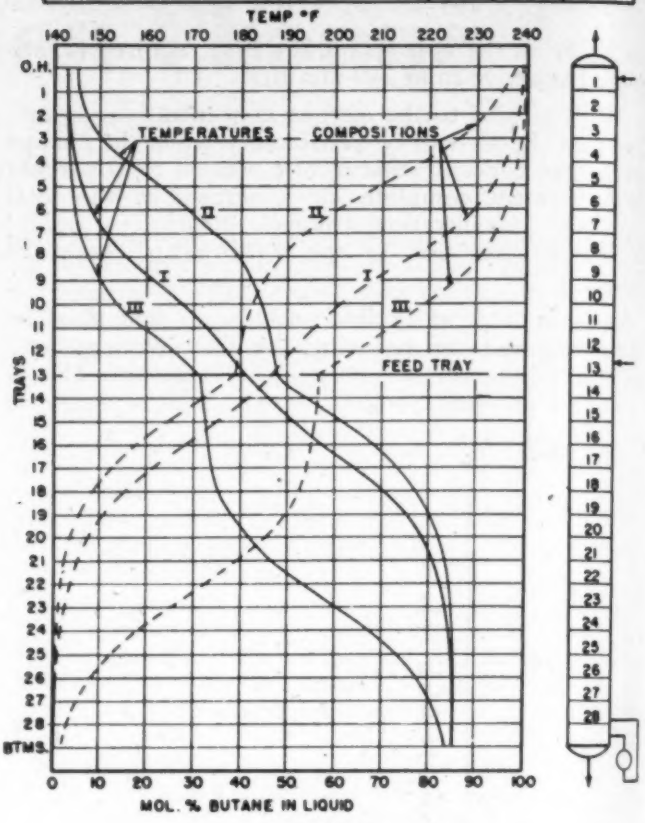


FIGURE 2
Debutanizer tray temperature and composition; effect of changing product rates with other conditions constant, including reflux rate.

In the application of control instruments, it is first necessary to establish the results that the process is expected to accomplish. If the process designer will supply all pertinent data on process performance and operating variables, the instrument system can be precisely designed to fit conditions that exist during actual operation. This data usually will include the following:

(1) Maximum and minimum flow rates, compositions, and product purities to be expected in feed and product streams.

(2) Process system temperatures and pressures.

(3) Surge capacity, or "holding time," allowed in various vessels.

(4) A process description that explains how and why the process works, both for normal design operation and for any alternate or possible emergency operations. Any available information on the effect of changes in operating conditions, and critical points of control should be noted.

There is usually information that does not appear on the process flow sheets or in the process descriptions which is nevertheless quite valuable for instrumentation design, and accordingly, it is very desirable that process designer and instrument application engineer work closely together.

For clarity it seems desirable to define certain distillation equipment items and functions, even though most readers may be thoroughly acquainted with

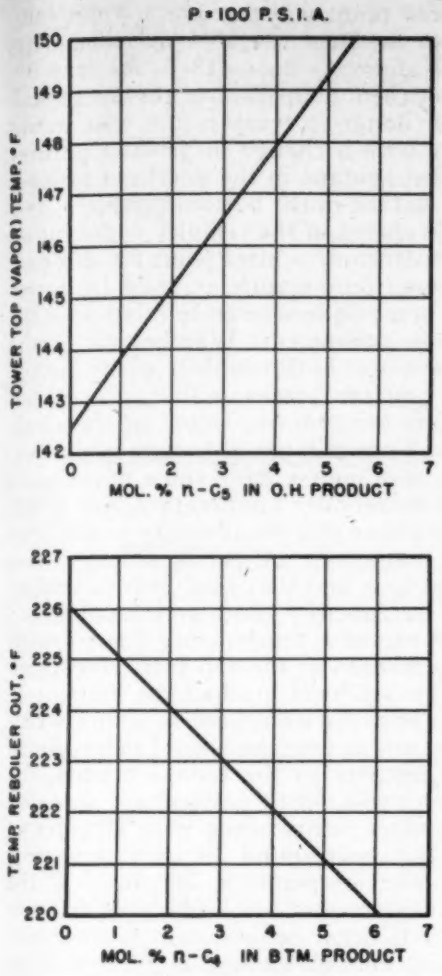


FIGURE 3
Effect of product composition on debutanizer tower top and bottom temperatures.

these factors. A typical distillation stage for separating light hydrocarbon feeds into an overhead product and a bottoms product is shown in Figure 1.

Such towers utilize a wide range of reflux ratio and contain a varying number of bubble-cap trays, depending on the difficulty of the separation to be performed and the sharpness of fractionation that is desired. Feed enters at some point in the tower midsection. Trays above the feed point are termed "fractionating trays" and serve to separate from the overhead product the heavier hydrocarbons of the feed stream that are to be included in the bottom product. Trays below the feed point are termed "stripping trays" and serve to "strip-out" from the bottom product the lighter hydrocarbons that are to be included in the overhead product. The overhead product and reflux leave the tower top tray in vapor state. Reflux must be condensed and returned to the tower top tray for the unit to function as a distillation apparatus.

Overhead product may be produced as a vapor, a liquid, or a combination of vapor and liquid, depending on the choice of the process designer, the composition of this product, the available water temperature, and the pressure at which it is desirable or practical to operate the tower. In any case reflux is condensed in a cooler at a temperature set by a reasonable approach to the available cooling water temperature. With overhead product produced as a vapor, the condenser outlet pressure and thus indirectly the tower pressure, is that pressure which corresponds to the "dew point" of the product vapor at cooler outlet temperature, as reflux could not be condensed at a lower pressure and a higher pressure would result in a condensation of product, which is not desired. If overhead product is to be totally condensed the pressure must be at least as high as the "bubble-point" pressure at cooler outlet temperature.

For any given cooler outlet temperature the lowest tower pressure will be required with a vapor as the top product, the highest with a totally condensed top product, and intermediate pressures will result in varying proportions of vapor and liquid.

Temperature at the bottom of the tower will correspond with the "bubble-point" of the bottom product at the tower pressure set by condensation requirements of the overhead product. In some cases this required temperature may be excessive from the standpoint of deterioration of bottom product, or because the available heat medium for the reboiler may not be at sufficient temperature level for satisfactory heat transfer, or for some other reason. Where a lower bottom temperature is necessary or desirable, tower pressure may be reduced by the use of a lower reflux condenser temperature.

Vapor Pressure Requirement

It is necessary to keep in mind the results most important for the particular case at hand. In the conventional gasoline stabilizer used for setting gasoline to the Reid vapor pressure currently desired for sales or blending purposes, the one important operating specification is the vapor pressure of the bottom product.

Variation in the percentages of heavier components in the stabilizer feed will require corresponding variations in the butane content of the gasoline to maintain a constant vapor pressure product. These variations if considerable may require a slight adjustment in reboiler outlet temperature; however, maintaining a constant reboiler outlet temperature and tower pressure has proven to be the most desirable method of control on a stabilizer. This is obvious when we analyze the Reid vapor pressure test. The problem is an old one and is mentioned here principally to clarify later discussion of other types of fractionating equipment.

In towers intended for the sharp separation of individual hydrocarbon components different considerations apply. In the case of a debutanizer, for instance, the bottoms product must be essentially butane free regardless of the vapor pressure, and instrumentation and operation must be set up to obtain this result. The resemblance between the actual physical equipment of a debutanizer and a gasoline stabilizer has been a cause of confusion and sometimes has resulted in faulty application of instruments when the real objectives of the control scheme have not been recognized by the instrument engineer.

With towers that produce an overhead product which can be totally condensed at available cooling water temperatures and reasonable tower pressures, as is usually the case with debutanizers, several interesting control factors are encountered. Reflux condenser size is set by the quantity of overhead product and reflux, condensing temperature, and cooling water temperature, and the physical characteristics of hot and cold fluids in the condenser. Whatever the size of the condenser, there will of necessity be a certain over-design of "safety factor" which represents the difference between the theoretically calculated surface area and the area considered adequate by the manufacturer who must guarantee condenser performance. This ability to transfer more heat than actually required by the

process design in practice can be controlled in various ways. The tower pressure can be lowered to the point dictated by the equilibrium temperature at the condenser outlet, or less cooling water can be circulated through the condenser thus raising the cooling water outlet temperature and decreasing the heat transfer because of lessened temperature difference (although this can cause serious boiler scale formation in the water tubes if carried too far).

Maintenance of Liquid Level

One very satisfactory method of control for total condensing operation is based on maintenance of a liquid level in the condenser proper. The ability of a condenser to function is dependent on the amount of surface exposed to the entering vapors. A higher liquid level in the condenser results in a lower condensing capacity for the unit, while the lowering of the liquid level to expose all the surface corresponds to the maximum capacity of the condenser.

Tower pressure serves to control the liquid level in the condenser, one scheme utilizing a controller which actuates a valve in the overhead product line to storage. Tower pressure builds up when enough product is condensed to raise the liquid level in the condenser and cover tubes with liquid until just enough surface is available to condense the overhead vapors. The pressure controller, as the set point is reached, opens the product control valve wider until an equilibrium condition is reached between pressure and liquid level. The control system shown in Figure 5 is a variation.

For towers used in the separation of specific hydrocarbon components a study of tower tray compositions is useful in the selection of suitable control instruments. Calculations were made* for a typical debutanizer having a feed composition of 50 percent normal butane and 50 percent normal pentane. Figure 2 shows calculated tray temperatures for varying product purities when the other tower operating variables are held constant. The curves I represent the desired operating conditions for the tower and correspond to the production of a bottoms product with 0.25 mol. percent butane included and an overhead product with 0.25 mol. percent pentane included. Product purity is the variable subject to control, the reflux ratio, tower pressure, and reboiler and condenser temperatures being held substantially constant. Small changes in product purity will of course result in slight variations in the reboiler and condenser equilibrium temperatures, but the effect is practically negligible. Curves II represent operation with the production of 0.06 mol. percent butane in the bottoms and with 2.0 mol. percent pentane in the overhead products. Curves III represent operation with the production of 2.02 mol. percent butane in the bottoms and with 0.08 mol. percent pentane in the overhead product. Note that the temperature and composition changes are small on the first several trays down from the top of the tower or on the first several trays up from the bottom of the tower, but that nearer the feed tray there is in each case a much greater change in compositions per tray and corresponding larger changes in tray temperatures. If a temperature control point is to be selected for this tower it is evident that the use of the top tray, or the bottom tray, will provide a temperature spread of approximately 2° F. for the variation in product purities indicated by the curves, while the use of a tray nearer the feed point will provide a wider temperature spread for the same range of product purity, as much as 32° F. for tray 9 or 41° F. for tray 19. The distances between temperature curves II and III represent the change in temperature that would occur in any tray with a change in product purities from 2 mol. percent pentane in the overhead product to 2 mol. percent butane in the bottom product.

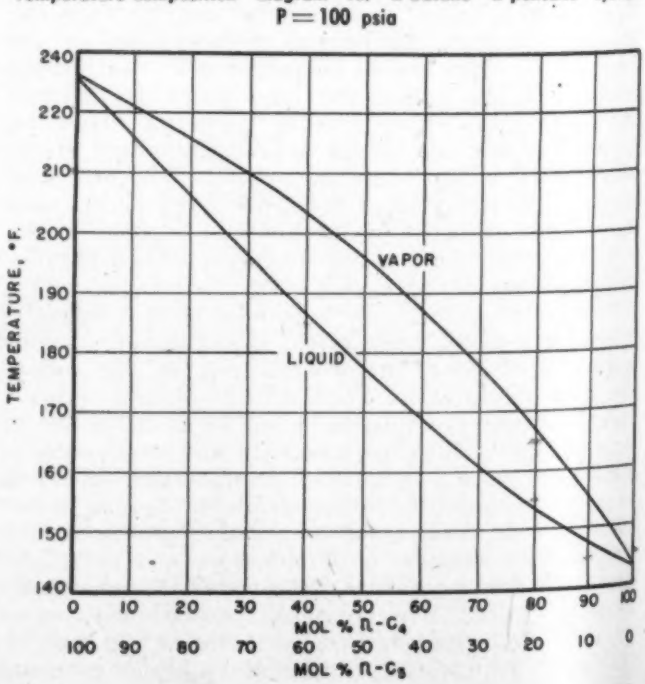
A thermocouple placed in the reboiler vapor outlet would not be a satisfactory control point for this case because the bottoms temperature is fixed by tower pressure and the pressure-temperature relation of the single hydrocarbon component. Whether all of the pentane leaves the tower bottom substantially butane free or half the pentane leaves with the overhead product, the bottom temperature would be the same.

Presence of small percentages of butane in the bottom product would of course have some effect upon the necessary tower reboiler temperature, but it has already been noted that this temperature is not very sensitive to the magnitude of purity changes that could be tolerated here and that this form of control could not be too satisfactory. Similar reasoning can be applied to the use of a temperature control with the thermocouple located at the top tray, since with only butane in the overhead product the amount of butane leaving as bottoms would not be indicated by the thermocouple, and if pentane should be produced overhead as an impurity in the butane stream, the temperature control will not be particularly sensitive to changes in product purity since wide changes in this product purity correspond to only a narrow change in top tower temperature. In either of the above cases it is evident that a considerable contamination would have to occur before a temperature controller would have enough change to be operative, assuming that tower pressure is held constant. On this particular tower it appears that use of the ninth tray with a temperature controller capable of control accuracy of plus or minus 1° F. would be about 10:1 better than the use of the top tower temperature.

In the somewhat similar case mentioned in the opening paragraphs special instrumentation was ap-

FIGURE 4

Temperature-composition diagram for n-butane—n-pentane system. P = 100 psia



* See acknowledgment at end of article.

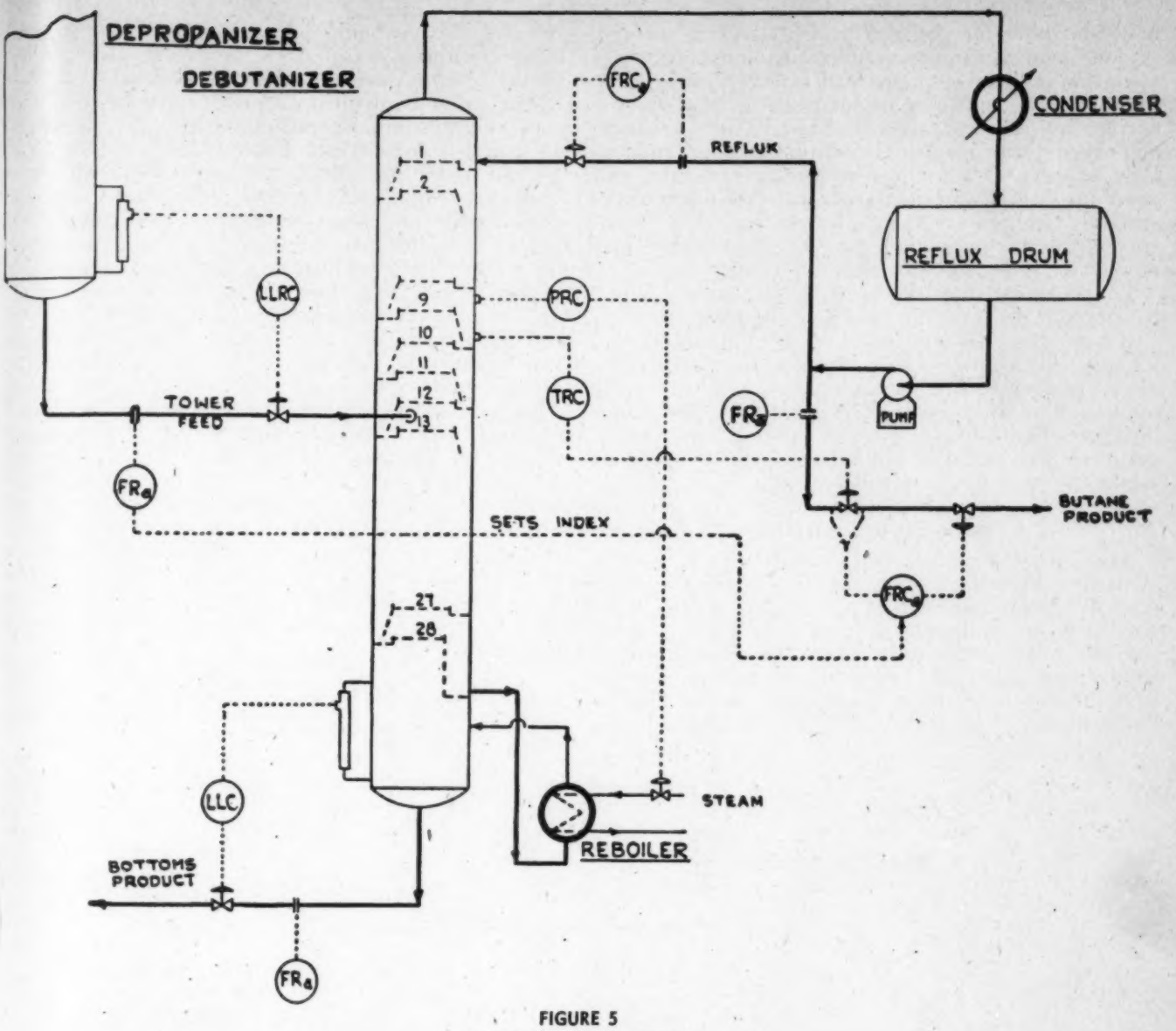


FIGURE 5
Debutanizer instrumentation

plied to a debutanizer that represented possibly the worst conditions to be encountered. As previously stated, feed was derived from several coking units on short time cyclic operation and passed first through a deheptanizer and then a depropanizer, and was finally available to the debutanizer with both a variable flow rate and variable composition. A flow diagram is shown in Figure 5. Holding time in the depropanizer was approximately 15 minutes, and this was utilized to the maximum practical extent by the use of an averaging type liquid level control on the bottom of the depropanizer. Alternately, a flow controller reset by a liquid level control, or a flow controller manually adjusted by the operator to simulate averaging type level control could have been used. A flow record was required in any case and pneumatic transmission instruments were used so that either method is available by switching the air transmission lines and reversing the control mechanism. Both records were carried on the same chart since they are directly related, and the control was provided with a valve positioner.

The reflux was flow-controlled at the rate specified by the process designer. The tower bottoms in this case are going direct to storage and were controlled by a throttling type liquid level regulator. If they had been going directly to another process or to a feed preheater they would be treated the same as the tower feed and provided with an averaging type liquid level control. This particular point is well worth attention.

It is perhaps usual practice to provide smooth control of tower bottom streams when they are sent on to another tower for further processing, but quite often bottoms passing through a tower feed preheat exchanger on their way to storage are controlled by a narrow range liquid level controller which causes sudden change in the flow rate of the bottoms stream and thus corresponding changes in the heat transferred to the tower feed by the exchanger, resulting in changes to the overall heat balance of the tower system and upsets in tower operating conditions. The process design specified totally condensed overhead product, tower pressure being set by vapor pressure of the butane overhead product at lowest practical condenser temperature with the available cooling water. For reasons stated the thermocouple for the tower temperature controller was placed in the ninth tray overflow liquid.

Variations in the feed rate to the tower are adjusted by means of a ratio type flow controller with an orifice in the feed line arranged to reset a

flow controller for the overhead product to storage. As long as feed composition remains constant, tower operation is little upset by feed rate variations since the ratio flow controller automatically establishes the correct split between overhead and bottom products and other tower operating conditions are not particularly concerned. Variation in feed composition will show up as a change in temperature on tower trays and the temperature controller on tray No. 9 will correct for this by setting the ratio flow control to a new split between overhead and bottom product.

In the actual installation this effect was obtained by the use of a variable orifice, a diaphragm control valve, for the flow controller on the butane product stream, this control valve being positioned by the tower temperature controller. Change in the valve opening here of course results in altering the orifice differential read by the product stream flowmeter at constant flow rates, or in effect changes the ratio at which the ratio flow controller is set.

Ratio Flow-Controller

An alternate and equally satisfactory scheme shown in Figure 6 makes use of a ratio flow controller capable of ratio variation by a pneumatic transmission temperature controller. It was noted that the tower pressure is set by the requirement of condensing reflux and overhead product. The tower pressure control here is actually applied to the reboiler heat medium supply stream, and results in the reboiler always being operated at the temperature level required to maintain the tower pressure selected by the process designer or the unit operator.

The other controlled factors will balance out at some equilibrium operating conditions and tower operation is entirely automatic. With controls set at desired operating points, the overhead product will build up a liquid level in the reflux drum and condenser until condenser surface is covered corresponding to equilibrium conditions. Any increase in this level above the equilibrium height will at once cause a rise in tower pressure because of the lower available surface to condense overhead vapors.

This pressure increase in turn will result in the tower pressure controller decreasing the heat to the reboiler and consequently the bottoms temperature. This temperature change will alter the split between overhead and bottoms product causing a temperature change on tray No. 9 at the tower temperature controller which will in turn cause alteration of the index setting of the ratio flow controller so that the proper amount of overhead product will be sent to storage to restore the correct equilibrium liquid level in the reflux condenser. Operation of the tower has been highly satisfactory both from the standpoint of product specifications and smoothness of operating control.

ACKNOWLEDGMENT

Calculation of tray temperatures and compositions for the debutanizer were performed by G. S. Houghland, The M. W. Kellogg Company, New York, and were invaluable to the author in working out the tower instrumentation scheme.

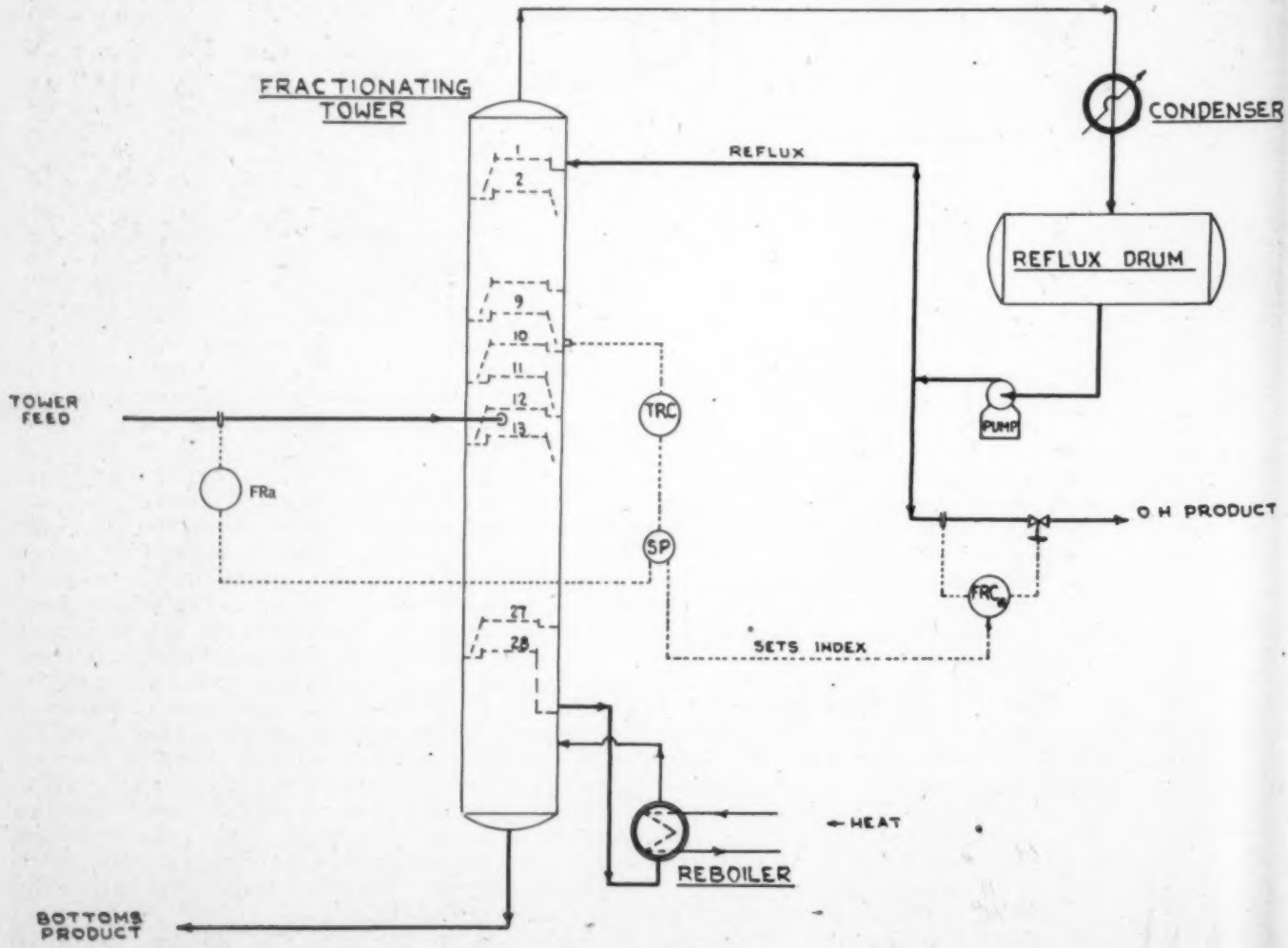


FIGURE 6
Proportioning ratio control

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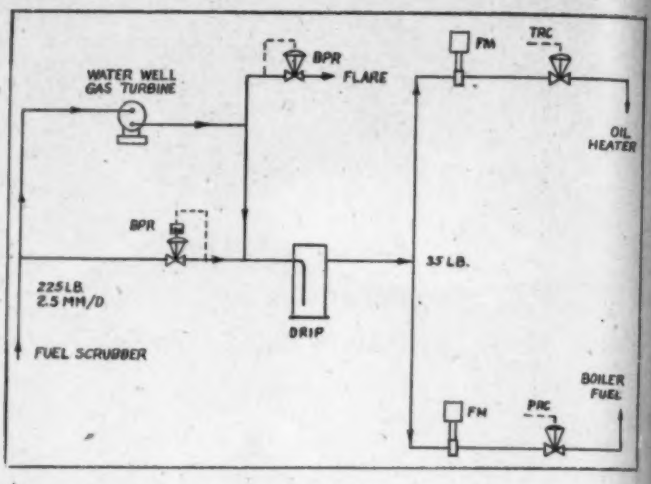


Shell plant for extracting energy from high-pressure gases and flow diagram of method.

HOW TO—

Utilize Energy in High-Pressure Gases

SAVINGS in utility requirements can often be effected in process units through the utilization of energy derived from the expansion of high-pressure gas streams. A method, used in the Sheridan Cycling Plant of Shell Oil Company, Inc., for extracting the available energy from 225 psig tail gas, while at the same time reducing its pressure to the 35 psig level required for fuel gas burner systems, is illustrated in the accompanying photograph and flow diagram.

Tail gases from a scrubber at 225 psig serve to drive a gas turbine in water well pump service. The turbine exhausts into the 35 psig fuel gas system where a drip tank removes any condensables and the gas flows to oil heater and boilers through individual flow meters. To accommodate variations in the production of tail gases in the 225 psig system, pressure control instruments are provided. A back pressure regulator vents any excess gas from the 35 psig system to the plant flare, and an additional pressure controller bypasses gas from the 225 psig system when the gas turbine is shut down or operated at low capacity. Flow of fuel gas to the furnaces is further controlled by a temperature recorder controller in the case of the oil heater, and by a pressure controller activated by live steam pressure in the case of the boilers.

HOW TO—

Prevent Damage to Heat Exchanger Tubes

A CRADLE-TYPE skid made of structural steel facilitates the moving of exchanger tube bundles to and from the shop. Damage to the tubes is eliminated as cross-members of the cradle support the tube sheets and spacers, removing the possibility of mashed tubes. The skids are of six-inch I beams. Hooks at each runner make for easy tying-on. The entire unit, fully loaded, may be easily moved by putting pipe or wooden dollies under the skids.

Photo above shows cradle-type skid which helps solve problem of moving heat exchanger tube bundles to and from shop with a minimum of damage.

HOW TO—

Relieve Suction Joint Of Vibration and Strain

TO RELIEVE the flange joint at the suction chamber of a steam pump of vibration and consequent strain, one refinery utilizes the extra heavy three-inch priming line as auxiliary support. The priming line crosses through the pump skid about three feet from the face of the pump, and lies some four inches below the nearest point in the suction.

A saddle of heavy boiler plate, cut to fit the circumference of the suction, is welded to the priming line and the flange bolts then pulled up as tightly as possible. After the pump has been operated a few days the flange bolts are gone over again and all slack taken. A light bead is then run between suction nipple and saddle, tying the two together rigidly.

All vibration of the extended pipe is thus snubbed, and the gasket relieved of twisting and cramping which, with a free suction, might result in air leaks and consequent drop in pump efficiency.

If, for any reason, the suction nipple must be removed, the bead on either priming line or suction nipple is burned off, and replaced after repairs have been completed.

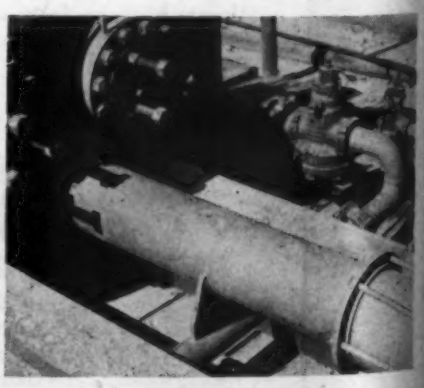
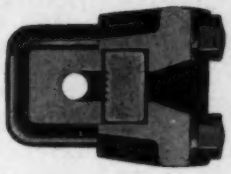


Photo above shows device designed to relieve flange joints at the suction chamber of a steam pump of vibration and strain.

Alike in Quality



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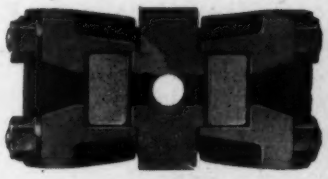

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HOW TO—

Make Neat Support For Loading Lines

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HOW TO—

Build Fire-Proof Compounding Structure

ROOSEVELT Oil Company, Mount Pleasant Mich., has erected a lubricating oil compounding building entirely of steel, much of which was salvaged material. Elevated floors for this building, are framed of standard structural shapes, and the floors are made of flattened sheets recovered from abandoned tanks. Floor sheets are tack-welded to the joists and the seams are continuously welded and ground to supply a smooth surface.

HOW TO—

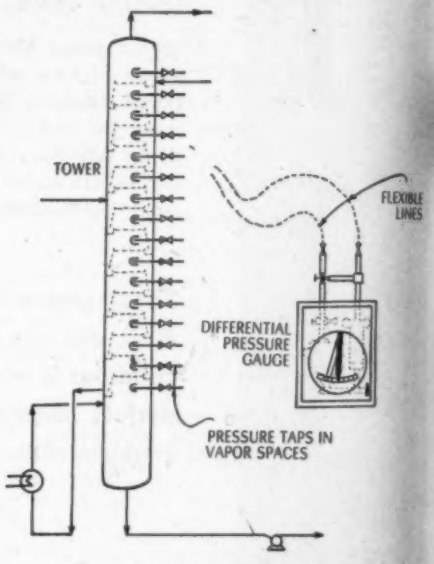
Locate Fouled Trays In Fractionators

AN OCCASIONAL source of trouble in process plants is the plugging of fractionating towers in service.

A method for avoiding the removal of each manhole and the inspection of each tray for obstructions when high tower pressure drops indicate the approach of inoperable conditions, is used successfully by some process plants. The method is simple, and involves only the measurement of the pressure differential between the trays of the tower while the unit is still in operation. This method definitely points out which trays are plugged before the unit shuts down and shortens down-time considerably.

Pressure measurement taps are necessary for measuring differential pressures across each tray. A series of small connections with gate valves are located one each in the vapor space above each tray and provide taps for measuring pressure conditions in the tower. Use of the gate valves will allow the insertion of a cleaning rod for clearing plugged connections should this ever prove necessary. The usual cleaning rod assembly familiar in every refinery is adequate.

Pressure differential can be measured by any convenient means. A mercury manometer can be carried up the tower and connected across each tray in turn while differential pressures are recorded, or if available, a bourdon tube or bellows type differential pressure gauge can be used. Perhaps the best arrangement is the use of a standard instrument type mercury manometer with indicating and



One method of measuring tray pressure differential.

set pointers such as are incorporated in differential pressure type liquid level instruments and direct-mechanical-connected flow meters. If this type gauge is used, it can be mounted at grade, or at some convenient tower platform level with flexible tubing used to make the requisite tower tray pressure connections. Normal care in draining the connecting lines and equalizing the mercury levels will, of course, be required for accurate results.

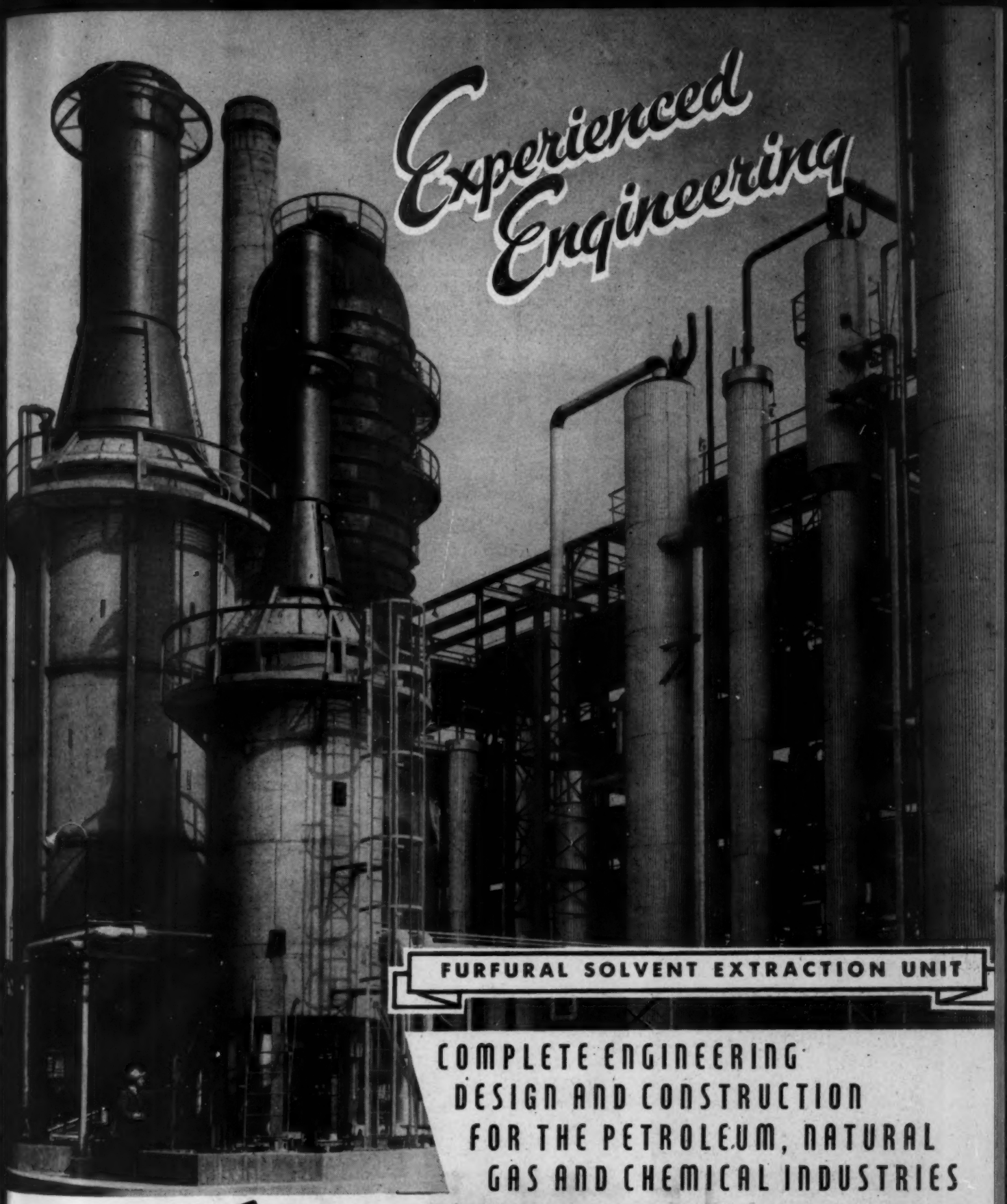
In cases where plugging of a particular tower causes frequent shutdowns, it may well be that a periodical schedule for checking tower tray pressure differentials can be followed to advantage.

Ceiling side of first floor in lube compounding building. Floors are made entirely of salvaged tank steel and structural steel joists and floor sills. Unit on tank is mixer used to blend oils for compounding lubes.

HOW TO—

Handle Emergency Repair of Rod Inserts

EMERGENCY repair of connecting rod bearing inserts, which prevent the prolonging of shutdown time, can be made by filling the channels and breaks in the old insert with new metal. While the measure should be considered as



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HOUDRY PROCESS
CORP.

PROCESS
Engineers, Inc.

2409 ROSS AVENUE DALLAS, TEXAS

Device for emergency bearing insert repair.

temporary at best, it will allow an engine to operate until permanent repair can be made.

The old insert should be thoroughly cleaned, the smallest welding tip that will furnish the necessary heat to melt the babbitt should be used. Flow the babbitt into the channels, runs and cracks of the bearing until they are the same level as the original metal. Use bearing scraper to obtain full bearing surface.

Engines repaired in the above manner have made extended runs.

HOW TO—

Rack Valves So As To Minimize Damage

VALVE stocking often presents an aggravating problem to the warehouseman. A rack which saves floor space, aids in keeping of inventory and stops damage is used by Maintenance Engineering Company of Houston, Texas. The photographs show stocks of Edwards valves on the rack in their warehouse.

Above, clip signs attached to valves in stock make it easy to ascertain status of every item.

Left, valve rack facilitates storage of valves in stock.

Slip signs, easily attached to valve handwheels enable stock clerks to keep an inventory of valves on hand, a glance showing status of the supply on hand. The rack, shown in the other photograph, makes location of particular valves easy, prevents damage to valves and saves space.

HOW TO—

Transfer Seal Oil For Instruments

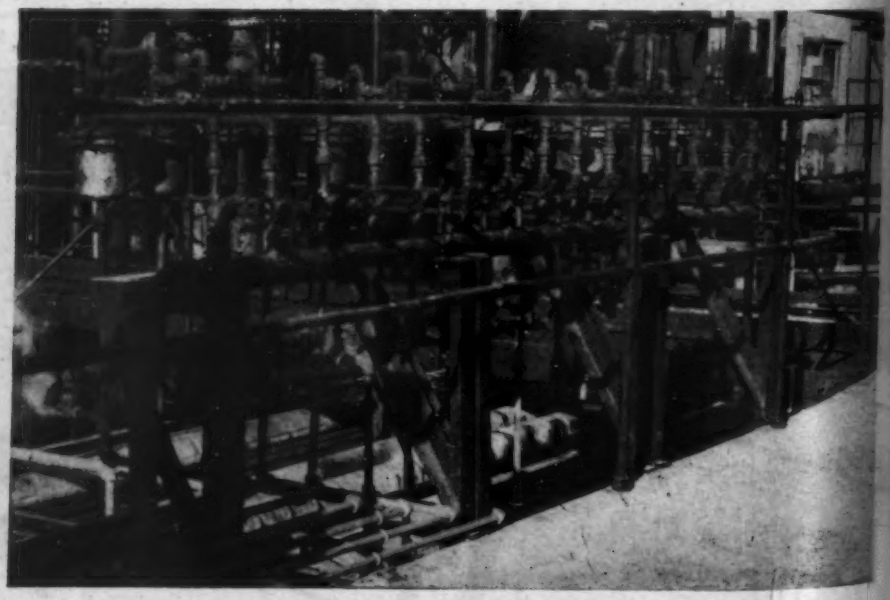
SHELL Oil Company employes at the Houston refinery have devised a portable compressed air supply cart which is used for transferring seal oil into instruments. This device eliminates costly hand labor in adding seal oil and has proved a real time saver.

Portable compressed air supply cart.

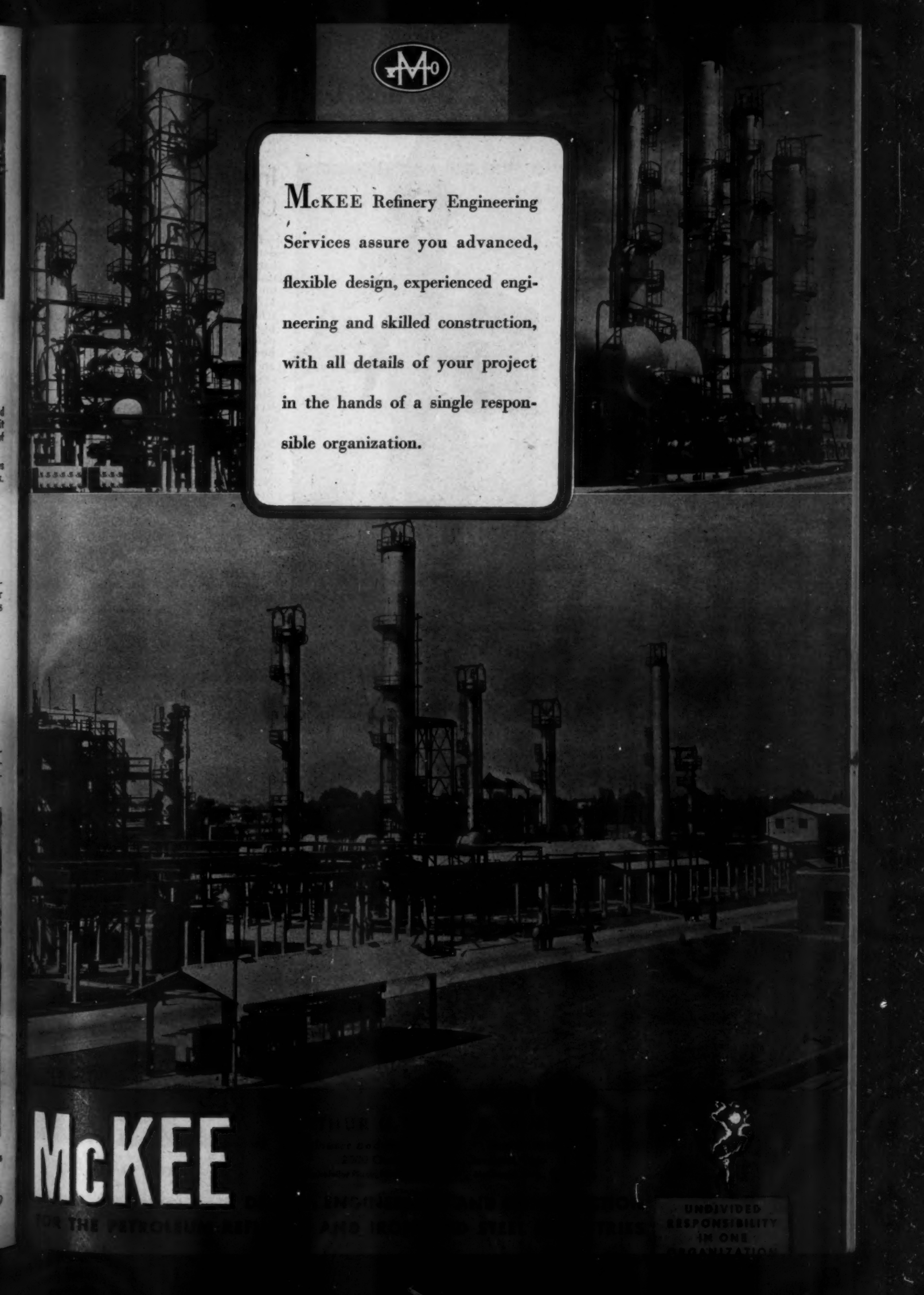
HOW TO—

Group Steam Traps for Efficiency

WHEN a number of steam traps are used in a process unit it is sometimes advantageous to group the traps on a common bracket where they are accessible for inspection and maintenance. Discharge piping, too, can often be simplified in such a case by the use of manifolds common to several traps.



Above photo shows a battery of small steam traps installed on bracket, a method which facilitates and expedites maintenance considerably.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UNDIVIDED RESPONSIBILITY IN ONE ORGANIZATION

REFINER AUTHORS . . . . . and OTHER PERSONALITIES

West Coast Man Writes on Catalyst

Robert C. Davidson, of Filtrol Corporation, Los Angeles, author of "Cracking Sulfur Stocks with Natural Catalyst" (starts on page 79) admits three main interests — two daughters and a son. This, we are going to add, is in addition to his research work with Filtrol Corporation, Los Angeles, where he is presently engaged in studying the technical aspects of catalyst sales. Needless to say he has gained in this work considerable experience in the application of clay catalyst for cracking petroleum.

Davidson is a native of Denver, Colo., where he was born in 1916 and where he lived until shortly before entering the California Institute of Technology where he received a B.S. in Applied Chemistry in 1938. Prior to graduation he got some refinery experience with Socony-Vacuum Oil Company in Michigan and after getting the degree he was employed by Filtrol as chemist in the technical service laboratories. Since then he has held several posts with Filtrol, including field service in finishing of lubricating oils and assistant director of research in charge of special projects.

R. C. DAVIDSON

A Fisherman, Too

Next is a much better fish than it is a photograph. E. D. Mattix, author of "Notes on the Control of Light Hydrocarbon Fractionators Subject to Variation in Feed Composition and Quantity", page 130 confesses to hobbies of hunting, fishing, photography and instruments, and apparently the photo, which

E. D. MATTIX AND FISH

the editors requested, is to prove that he isn't a flop when it comes to at least one of his avocations—deep sea fishing. Mattix didn't say, but Refiner office consultation came to the conclusion that his fish is a ling, a sporty fellow with lots of fight when you hook him. If we're wrong, some of our readers doubtless will set us straight. Which is enough about the fish.

Mattix, who is technical advisor on instruments for Cities Service Refining Corporation, currently is located at The Tutwiler Refinery of that company, Lake Charles, La. He was born in Ohio April, 1910 and received his schooling there. His work has been in conjunction with oil refining for the past 16 years, including operation, instrument maintenance, construction and engineering.

Early Prize Winner

Weller R. Pierce, whose paper "Relationship of Reflux to Feed for a Fractionating Column" commences on page 92, started off by winning a prize in the American Institute of Chemical Engineers annual student contest problem (1941) in which year he was graduated from Clarkson College of Technology, Potsdam, N. Y., with a degree of Bachelor of Chemical Engineering.

Since graduation he had been engaged

. . . . CONTINUED ON PAGE 145

Insulation Expert Contributes Article

Larry A. Hanson, president and founder of Marine Engineering & Supply Company, Los Angeles and Wilmington, Calif.,—he's author of "Insulation Data on a Large Combination Unit," page 112—has a background of broad industrial experience. In the steel, shipbuilding and insulation fields he has held positions ranging from storekeeper and purchasing agent to general manager and president.

Starting as storekeeper at Carnegie Steel Company's Union Mills in Youngstown, Ohio, Hanson became connected with the shipbuilding industry following World War I. At that time he was with Southwestern Shipbuilding Company in San Pedro (now the Bethlehem Shipbuilding Division) and then was purchasing agent and later general manager of the Los Angeles Shipbuilding and Drydocks Corporation.

In 1927, he organized the Marine Engineering & Supply Company, one of the West's leading technical insulation firms, specializing in large-scale insulating operations. Thousands of installations have been handled for insulation involving temperatures of 400° F. below zero to 2600° F. above. He is also president and founder of asbestos, Engineering & Supply Company of Phoenix, an Arizona corporation covering that state.

A resident of Altadena, Calif., Hanson's hobbies include riding and golf.

Hanson has two children, both also married. One son is a graduate of the California Institute of Technology and is associated as an engineer with the Marine Engineering & Supply Company.

LARRY A. HANSON

Authors

■ CONTINUED FROM PAGE 142

in the development, design and operation of plants manufacturing natural gasoline, aviation gasoline, synthetic rubber and special hydrocarbons. His first employment was with The Atlantic Refining Company, Philadelphia, in the research and development department. Then he became process engineer in the petroleum refinery division of Foster Wheeler Corporation, New York. His present job —with a major oil company—involves the economic evaluation of new processes and the design of plants that can utilize petroleum as raw materials.

We wanted to show his picture on this page, but dispatch of the likeness was delayed by an important vacation.

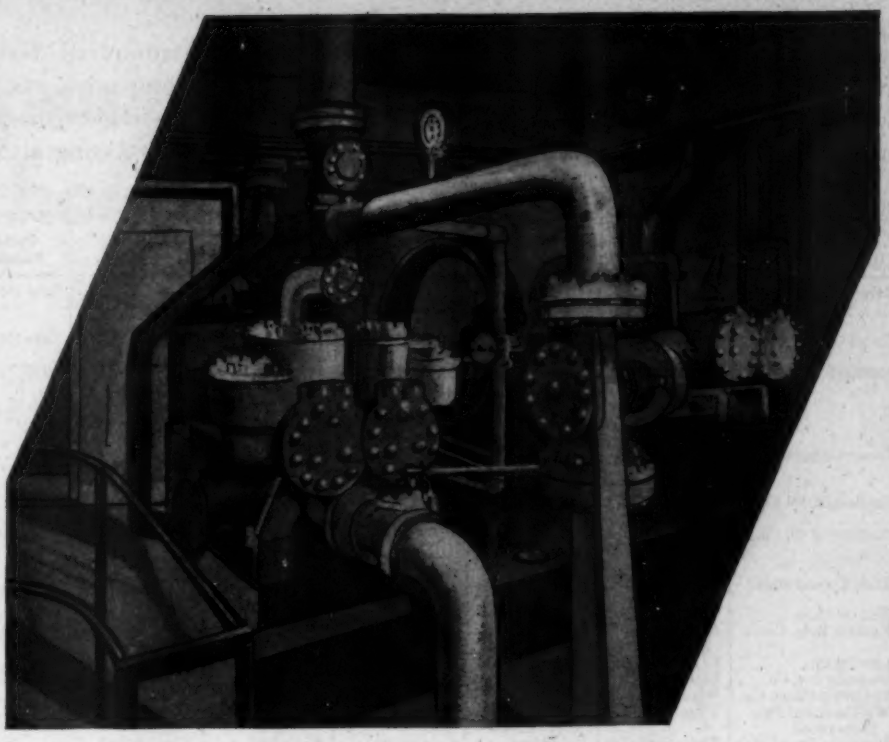
DR. WILLIAM C. FRISHE

WILLIAM C. FRISHE, professor of Chemical Engineering and Metallurgy, Grove City College, Grove City, Pa., author of "Calculation of Concentration Change" which starts on page 128, is well known to REFINER readers.

His first contact with the petroleum industry was in the summer after his junior year in college (1934) when he worked at the Latonia, Ky., refinery of Standard Oil Company (Ohio), first in the gasoline laboratory and then in the plant for removing mercaptan sulfur.

After graduation from Maryville College in Tennessee, he worked for a paint company before taking post-graduate work at Kentucky and Cincinnati. He's been teaching most of the years since (Rochester, Minn., Junior College, Alabama Polytechnic), this prior to taking his Ph. D. degree at Indiana University. Before going back to Auburn as assistant professor of chemical engineering (1945-46), he worked as development engineer in the gas process division of Girdler Corporation, Louisville, Ky., chiefly on engineering of hydrogen generation and purification plants. He went to Grove City in June, 1946.

You shudder to think of a fire here!



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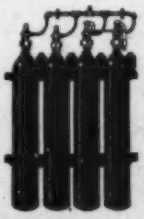
PUMP rooms, solvent extractors, de-waxers, laboratories, stills—any area in your plant where petroleum is processed —call for quick fire detection and extinguishing. A C-O-Two Automatic System gives you this *complete* protection. The moment fire starts, a rate-of-rise or fixed temperature detector operates the system. Before damage is done, the fire is blanketed in clouds of cold, dry carbon dioxide gas-and-snow. Out in seconds!

C-O-Two is clean, modern fire protection. It is especially suited for petroleum and other flammable liquid fires. Can be used on running electric equipment because it's non-conducting. C-O-Two never corrodes metals or damages delicate instruments. When the fire is out, C-O-Two disappears without a trace.

Let an expert help you plan your fire protection. Write us for more information about C-O-Two today.



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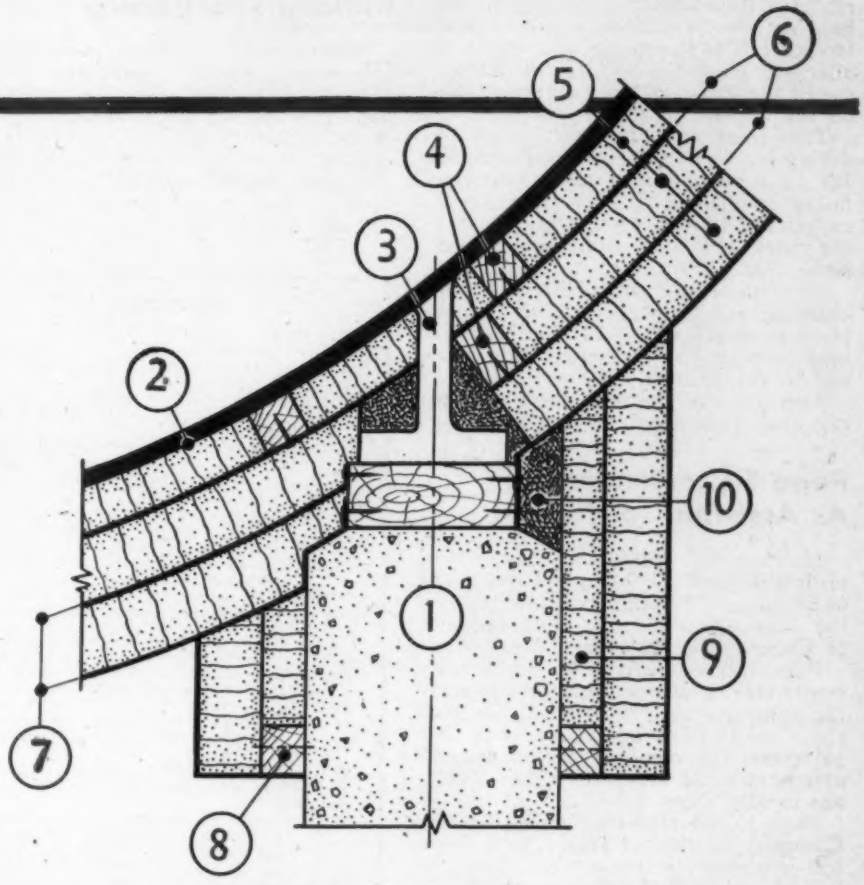
Refinery and Plant Construction

In the tabulation below is presented some of the refinery and plant construction work that is under way or projected at the present time. From month to month other projects will be added until, it is hoped, a complete "box score" will be possible each month. Companies are asked to send in details which are missing in this, the first such tabulation. Units that are missing altogether are particularly desired.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Bareco Oil Co.	Wichita, Kans.	Cat desulfurization and cat reforming	.....	$500,000	.....	Late 1947	Phillips Pet. Co.	Koch Eng. Co.	Koch Eng. Co.
Carter Oil Co.	Billings, Mont.	Crude and cat cracking	20,000 bbls.	.....	Work started	Late 1948	.....	.....	.....
Carthage Hydrocol, Inc.	Brownsville, Texas	Synthine	64,000 mcf	$19 million	Under constr.	1948	Hydrocarbon Research, Inc., Texaco Dev. Co.	.....	Arthur G. McKee Constr. Co.
Citcon Corporation	L. Charles, La.	Lube plant	6,000	$30 million	.....	.....	.....	.....	Lummus Co. Max. B. Miller Co.
Continental Oil Co.	Billings, Mont.	Cat cracking	7,500 bbls. daily	$8.5 million	Contract signed	1948	.....	.....	Jones & Laughlin Supply Co.
Continental Oil Co.	Denver, Colo.	Crude topping cat poly, cat crack	16,600 bbls. daily	$4 million	Work started	Fall 1948	Universal Oil Products Co.	Continental Oil Co.	Lummus Co.
Ethyl Corporation	Baton Rouge, La.	Manufacturing facilities.	.....	$20 million	Announcement	.....	.....	.....	.....
Gulf Oil Corp.	Crane Cty, Tex.	Gasoline plant	23,000 mcf	.....	.....	.....	.....	.....	.....
Kanotex Refg. Co.	Arkansas City, Kansas	Cat. cracking	.....	.....	Contract let	Early in 1948	Phillips Pet. Co.	.....	Koch Eng. Co.
Lion Oil Co.	El Dorado, Ark.	Cat. cracking	4,500 bbls.	.....	.....	.....	.....	.....	.....
Magnolia Pet. Co.	Beaumont, Tex.	Lube unit	.....	.....	Under constr.	Jan. 1, 1949	.....	.....	.....
McCarthy Chem. Co.	Winnie, Tex.	Petro-chem	.....	$3 million	Breaking ground	.....	.....	.....	.....
Mid-Continent Pet. Corporation	Tulsa	Vacuum still, fluid cat crack	45,000 bbls.	$8½ million	Contracts let	.....	.....	W. M. Kellogg Co.	W. M. Kellogg Co.
Monsanto Chemical Co.	Texas City, Tex.	Rebuilding Perto-chem	.....	$6 million	Contracts let	.....	.....	.....	W. S. Bellows Co. Leonard constr.
Ohio Oil Co.	Robinson, Ill.	Vacuum pipe still, fluid cat cracking	39,900 bbls.	$15 million	Announcement	Late 1948	.....	.....	.....
Pan American Refg. Corporation	Stone plant, Texas City	Repairs, replace damage	6,000 bbls.	.....	.....	.....	.....	.....	.....
Plomo Company	Nueces Co., Tex.	Gasoline plant	.....	.....	Awaiting R. R. Comm. approval	.....	.....	.....	.....
Porto Marghera Refg.	Venice, Italy	Enlarging plant	.....	.....	.....	.....	.....	.....	.....
Pure Oil Company	Smith's Bluff, Texas	Lube plant	.....	$9 million	Contracts being let	.....	.....	.....	.....
Shell Chemical Co.	Thornton, Eng.	Petro-chem	.....	Several millions	In progress	.....	.....	.....	.....
Shell Chemical Co.	Shell Haven, Essex, England	Petro-Chem	.....	.....	.....	.....	.....	.....	.....
Shell Chemical Co.	Stanlow, Eng.	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Chemical Co.	Houston, Texas	Glycol	.....	Part $25 million	In progress	Early 1948	.....	.....	W. M. Kellogg Co.
Shell Chemical Co.	Shell Point, California	Synthetic ammonia	.....	.....	.....	1948	.....	.....	.....
Shell Oil Company	Notrees, Texas	Gasoline plant	40,000 mcf	.....	Under constr.	.....	.....	.....	.....
Shell Oil Company	Houston, Texas	Lube unit	.....	$10 million	Construction approved	.....	.....	.....	.....
Sid W. Richardson	Keystone Field	Gasoline unit	70,000 mcf	.....	Constr. approved	.....	.....	.....	.....
Socony-Vacuum Oil Company, Inc.	Paulsboro, New Jersey	Lube plant	.....	.....	Under constr.	Jan. 1, 1949	.....	.....	.....
Socony-Vacuum Oil Company, Inc.	E. St. Louis, Ill.	Delayed coker and distillation	.....	.....	Under constr.	Jan. 1, 1949	.....	.....	.....
Socony-Vacuum Oil Company, Inc.	Casper, Wyoming	Cat cracking	5,000	.....	Under constr.	Jan. 1, 1949	.....	.....	.....
Socony-Vacuum Oil Company	Augusta, Kans.	Cat cracking	10,000 bbls.	.....	Under constr.	Jan. 1, 1949	.....	.....	.....
Stanolind Oil & Gas Company	Hugoton, Ind.	Gasoline	.....	.....	Projected	1949	.....	.....	.....
Socony-Vacuum Oil Co., White Eagle Division	Augusta, Kansas	Cat cracking	4,000	.....	Contract let	Early 1948	.....	.....	Catalytic Construction Co.
Stanolind Oil & Gas Company	Brownsville, Texas	Chemical recovery unit	100 million lbs. yearly	.....	.....	.....	.....	.....	.....
Stanolind Oil & Gas Company	Elk Basin, Wyoming	Gasoline plant	12,000 mcf	.....	Approved	.....	.....	.....	.....
Stanolind Oil & Gas Company	Hugoton, Indiana	Chemical recovery unit	100 million lbs. yearly	.....	.....	1949	.....	.....	.....
Standard Oil Co., (Indiana)	Sugar Creek, Missouri	Cat cracking	.....	.....	.....	.....	.....	.....	.....
Standard Oil Co., (Indiana)	Whiting, Indiana	Cat cracking	.....	.....	.....	.....	.....	.....	.....
Standard Oil Co., of New Jersey	Linden, New Jersey	Vac. cat cracking, pipe still	90,000 bbls.	.....	Contract let	1949	.....	.....	C. F. Braun Co
Standard Oil Co., of California	Richmond, California	Grease	.....	.....	Piling driven	.....	.....	.....	.....
Standard Oil Co., of Ohio	Lima, Ohio	Cat cracking	6,000	$10 million	.....	Late 1948	.....	.....	.....
Sun Oil Company	Richland Parish, La.	Gasoline	70,000 gallons	.....	Work strated	.....	.....	.....	Pet. Engs, Inc.
Sunray Oil Corp.	Duncan, Okla.	Crude topping	20,000 bbls.	$2 million	.....	.....	.....	.....	.....
The Texas Company	Eagle Point, New Jersey	Vac. still, fluid cat cracking	42,000 bbls.	.....	Contracts let	Late 1949	W. M. Kellogg Company	.....	W. M. Kellogg Company Foster Wheeler
The Texas Company	Lawrenceville, Illinois	Crude and cat cracking	.....	.....	.....	.....	.....	.....	.....
The Texas Company	West Tulsa, Oklahoma	Crude and cat cracking	.....	.....	.....	.....	.....	.....	.....
The Texas Company	Pt. Arthur, Tex.	Lube addition	.....	.....	.....	.....	.....	.....	.....
The Texas Company	Casper, Wyoming	Cat poly Naphtha reformer pressure coker	.....	.....	Under constr.	.....	W. M. Kellogg Company	W. M. Kellogg Company	W. M. Kellogg Company

How to insulate the supports of a horizontal tank



1. Concrete support
2. Tank shell primed with Armstrong's No. 4 Asphaltic Paint
3. Tank leg
4. Horizontal wood strips
5. Layers of Armstrong's Corkboard scored one way across narrow dimension of board
6. Galvanized bands spaced on 9" to 12" centers and nailed to horizontal strips of wood
7. Galvanized bands nailed to wood under tank leg
8. Wood strips anchored to concrete support
9. Corkboard applied to concrete pier
10. Brine putty or regranulated cork and asphalt fill all voids

Insulating the supports of a low-temperature tank as carefully as the tank itself prevents damaging frost formation and deterioration of the insulation at the points where the supports run through the insulation. Armstrong has worked out a number of practical methods of eliminating moisture and frost at these points. One method is shown above. This tank is over 54" in diameter and has metal legs supported by concrete piers. Armstrong's Corkboard can be applied to tank and supports in any desired thickness.

Holding low temperatures in refinery equipment presents a number of special problems—of engineering, application, and maintenance. Armstrong has been solving such problems for more than 40 years. If you are using thermal processes of any kind, an Armstrong engineer can probably suggest several uses of insulation that will profitably increase your plant's efficiency. For full information write to Armstrong Cork Co., Building Materials Division, 7509 Concord Street, Lancaster, Pa.

See Armstrong's advertisement, "How an Oil Refinery Operates" . . . The Saturday Evening Post, Sept. 27

*T. M. REG. U. S. PAT. OFF. PITTSBURGH CORNING CORP.

ARMSTRONG'S INDUSTRIAL INSULATION

Complete Contract Service For All Temperatures

From 300° Below Zero

To 2800° Fahrenheit

THE MONTH IN THE INDUSTRY

Sunray Is High Bidder On Refinery At Duncan

Suray Oil Corporation's high bid of $5.1 million for the Associated Refineries wartime plant at Duncan, Okla., has been accepted by WAA.

Sunray offered the highest figure, and reported it would spend nearly $2 million for modernization and additional facilities. The company also made an alternate lease bid to use the refinery for 10 years on a sliding rent scale based on the amount of production.

The Duncan refinery was operated during the war by Associated Refineries, Inc., a combination of about seven refining companies. It has a catalytic capacity of 10 to 15,000 barrels of charging stock a day, depending on conversion.

Since there are no facilities to make charging stock from crude oil, Sunray plans to install a 20,000-barrel crude oil topping plant to provide charging stock and to modernize the refinery.

Acquisition of the property gives Sunray three refining plants.

Page Succeeds Surface As Assistant to Holman

Howard W. Page, head of the Coordination and Economics Department of Standard Oil Company (New Jersey), has been appointed executive assistant to Eugene Holman, president.

Page succeeds Frank M. Surface, recently retired, who will continue to serve the company as a consultant. To head the Coordination and Economics Department, the company announced the appointment of Jerry A. Cogan, assistant to Mr. Page.

Page joined Humble Oil & Refining Company, affiliate of Jersey, as a chemical engineer 18 years ago. Later he served as a design engineer for the Standard Oil Development Company and as assistant manager of the European refining office of the Standard Oil Company (New Jersey). He returned to the United States after the fall of France, and became an engineering analyst for Jersey. He served both PIWC and PAW during the war.

Cogan joined the Standard Oil Company of Louisiana, a Jersey affiliate, in 1932, worked as a process engineer in the Baton Rouge, La., refinery and then came to New York in 1934 to become a member of Jersey's coordination manufacturing group. He became assistant head of the department in November 1945 upon his return from service with PAW.

Kanotex to Modernize Its Arkansas City Plant

Kanotex Refining Company has completed arrangements for modernizing its Arkansas City, Kans., refinery, according to F. A. Deering, general superintendent of refining.

The program includes a Perco catalytic desulfurization-catalytic reforming unit, licensed by Phillips Petroleum Company, Bartlesville, Okla.; revamping and enlargement of vapor recovery and catalytic polymerization facilities.

Koch Engineering Company, Wichita, Kans., has contracted for the engineering and construction work. The entire program is scheduled for completion early in 1948.

Indiana Sets Record

Standard Oil Company (Indiana) and subsidiaries hit new gasoline output highs in July, the company's twelve refineries boosting their crude runs to about 385,000 barrels daily.

For the whole of 1946 refinery runs averaged 341,000 barrels. In 1941, last prewar year, refinery runs averaged 308,000 barrels per day.

Meetings

September

8-12—Instrument Society of America, conference and exhibit, Stevens Hotel, Chicago.

15-17—National Butane-Propane Association, Jefferson Hotel, St. Louis.

15-19—American Chemical Society, Division of Petroleum Chemistry, annual meeting, Waldorf-Astoria, New York.

17-19—National Petroleum Association, Hotel Traymore, Atlantic City, New Jersey.

23-25—Pacific Coast Gas Association, Coronado Hotel, San Diego.

28 to Oct. 2—American Institute of Mining and Metallurgical Engineers, Petroleum Division, two-day technical meeting, Shirley Savoy Hotel, Denver.

29-30—Independent Petroleum Association of America, Oklahoma City.

29 to Oct. 1—American Institute of Chemical Engineers, Regional Meeting, Statler Hotel, Buffalo, N. Y.

29 to Oct. 3—American Gas Assocaition, San Francisco.

October

6- 8—American Society of Mechanical Engineers, Petroleum Mechanical Engineering conference, Rice Hotel, Houston.

6- 8—American Gas Association, Annual Meeting, Auditorium Hotel, Cleveland.

6- 9—American Society for Testing Materials, Statler Hotel, Detroit.

6-10—National Safety Congress & Exposition, Stevens, Sherman Hotels, Chicago.

15-18—Electrochemical Society Fall Congress, Copley-Plaza Hotel, Boston.

16-18—National Lubricating Grease Institute, annual meeting, Edgewater Beach Hotel, Chicago.

18-24—American Society for Metals Exposition, International Ampi-Theater, Chicago.

20-24—Annual Meeting, American Society for Metals, Palmer House, Chicago.

20-24—Annual Meeting, American Welding Society, Sherman Hotel, Chicago.

21-25—Pacific Chemical Exposition, San Francisco, Civic Auditorium.

November

6- 7—Society of Automotive Engineers, fuels and lubricants meeting, Hotel Mayo, Tulsa.

9-12—American Institute of Chemical Engineers, annual meeting, Statler Hotel, Detroit.

10-13—American Petroleum Institute, Stevens Hotel, Chicago.

December

1- 5—American Society of Mechanical Engineers, annual meeting, Atlantic City, N. J.

1- 6—21st Exposition of Chemical Industries, Grand Central Palace, New York.

29-30—Fourteenth Annual Chemical Symposium, American Chemical Society, Chicago.

Imperial Plans Removal Of Refinery to Alberta

Imperial Oil, Ltd., will spend between $6 and $7 million to dismantle, move and re-establish at Edmonton, Alberta, the Canol Project No. 1 refinery at Whitehorse, purchased from the U. S. Government for $1 million. Crude from the new Leduc field would be processed.

A new plant could be built at the same cost, it was pointed out, but the removal plan would put the refinery in operation by the end of 1948 whereas, because of material shortages, at least 18 months would be required for building a new structure.

Stanolind to Sell Synthol Plant Products to U.S.I.

The recently announced contract between Stanolind Oil and Gas Company and U. S. Industrial Chemicals, Inc., covers the sale of water-soluble oxygenated hydrocarbon chemicals produced both by the synthetic gasoline plant planned for construction by Carthage Hydrocol, Inc., and the plant to be erected by Stanolind Oil and Gas Company, E. F. Bullard, president of Stanolind, announced last month. Stanolind plans to build chemical recovery and separation plants adjacent to each of the synthetic gasoline plants and plans to refine the by-product chemicals to meet current trade specifications. U.S.I. plans to build plants at the two locations to manufacture an additional line of chemicals using part of Stanolind's Fischer-Tropsch chemicals as raw materials. Chemicals not consumed by U.S.I. in its operations will be sold as such.

Bullard pointed out that each of the synthetic gasoline plants, which employ a greatly improved version of the German Fischer-Tropsch process, is expected to produce upwards of 100 million pounds per year of water-soluble oxygenated hydrocarbons. These chemicals for the most part consist of straight-chain alcohols, aldehydes, acids and ketones containing from two to four carbon atoms per molecule. These products are basic for use as solvents and as raw materials in many industries such as rayon, plastics, pharmaceuticals, and others. Certain of the chemicals, however, will be made available for the first time in quantity and at reasonable prices by this new development. Stanolind's production is expected to commence in about two years and will contribute greatly to easing current shortages in ethyl and butyl alcohol, acetic acid and other chemicals.

Stanolind has not yet completed its plans for refining and marketing the higher molecular weight alcohols, acids, aldehydes and ketones containing 5 to 12 or more carbon atoms per molecule, which will be produced by the two synthetic gasoline plants. Stanolind's recovery and refining of these products will make available to the chemical industry a line of chemicals never before available in quantity and at reasonable prices, and will open up many avenues

OF "KARBATE" IMPERVIOUS GRAPHITE

FOR CONVEYING, processing, and storage of corrosive fluids, whole systems are now built 100% of "Karbate" impervious graphite. Complete equipment is available—the pipe itself, fittings, valves, pumps, heat exchangers, towers—for processing HF, HCl, H_2SO_4, and many other chemicals.

This lightweight equipment is easy to install. The pipe is readily cut and fitted in the field.

Standard "Karbate" pipe sizes range from 1" to 10" i.d. A full assortment of fittings can be shipped for each size. All parts made of "Karbate" impervious graphite are strong . . . immune to thermal shock . . . and offer the highest resistance to corrosion of any practical high heat-transfer material.

For additional information on "Karbate" impervious graphite for handling corrosive fluids, write to National Carbon Company, Inc., Dept. PR.

The term "Karbate" is a registered trade-mark of

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

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Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

THE MONTH...

for economical development of new processes and products.

U.S.I. is said to be in a particularly favorable position to handle these products what with its experience in serving industries using these chemicals, its nationwide distribution facilities, its trained technical personnel, and well-developed production techniques.

Important contributions will also be made by use of processes developed by U.S.I. for conversion of some of the primary products into other chemicals.

During the time the plants are being completed, U.S.I. has announced it will supply all possible technical assistance to users of these new products, so adequate data will be obtained in sufficient time to take full advantage of their availability.

Two Additions to Houdry Staff Are Announced

Two personnel changes made last month by Houdry Process Corporation, Philadelphia, include:

Whitney Weinrich, long experienced in petroleum research and development, became a member of the Houdry Laboratories as head of pilot plant development; and

Dr. Luigi G. Castellia, prominent South American businessman and petroleum refining authority, was named South American representative.

Weinrich who served as secretary of American Chemical Society's Division of Industrial and Engineering Chemistry from 1939 to 1943, joins Houdry after serving as a member of the staff of the Towne Scientific School, University of Pennsylvania, where he taught chemical engineering for the past year. Previously he had served Gulf Research as division chief of the chemical engineering group. During the war he was with PAW in the toluene and aromatics programs, later joining Phillips Petroleum Company as manager of its Bartlesville pilot plant section.

Headquarters for Castellia is in Buenos Aires, Argentina, where he has had extensive experience in the petroleum and industrial fields. He has been connected with the engineering department of the Public Service Corporation of New Jersey, has served as consulting engineer in charge of foreign business for Seabrook Engineering Corporation, and has been general Latin-American representative for The Lummus Company.

C. E. REISTLE, JR.

Sarco Offices Moved

Sarco Company, Inc., manufacturers of steam specialties, removed its head offices effective September 1 to the Empire State Building, New York.

WHITNEY WEINRICH

L. G. CASTELLI

Petroleum Engineering Group of ASME Meet

Sessions of the annual Petroleum Mechanical Engineering Conference of the American Society of Mechanical Engineers will be held at the Rice Hotel in Houston on October 6, 7, 8, registration beginning October 5.

Papers on mechanical engineering problems in all phases of the petroleum industry—production, transportation, refining and equipment—will be presented and field trips to inspect the vast petrochemical industry located around Houston are included.

Carl E. Reistle, Jr., general manager for production operations of the Humble Oil & Refining Company, is conference chairman.

The program includes:

"Heavy Crude Oil and Fuel Oil Handling," E. L. Adams, General Petroleum Corporation.

"Application of New Designs in Plunger Pumps with Comments on Handling of Viscous Crudes," L. T. Gibbs, Aldrich Pump and T. R. Aude, Stanolind Pipe Line Company, Tulsa.

"Study in Weldments in Alloy Steels and in Alloys," T. N. Armstrong, The International Nickel Company.

"History of Some Austenitic (18-8) Furnace Tubes," C. S. Pugsley, Standard Oil of New Jersey, Baton Rouge, La.

"Internally Insulated Piping and Pressure Vessels for High-Temperature Service," P. E. Darling, Pan American Refining Company, Texas City.

"Effect of Leakage Around Cross-Baffles in a Heat Exchanger," A. M. Whistler, C. F. Braun & Company, Alhambra, Calif.

"Investigation of Stress in Vessels under Internal Pressure," T. L. White, Commercial Shearing & Stamping Company, Youngstown, Ohio.

"Manufacture and Application of Composite Plates," O. R. Carpenter, Babcock & Wilcox Company.

Houdry Buys Plant

The modern catalyst-manufacturing plant at Paulsboro, N. J., operated by Houdry Process Corporation since 1942, under lease with the government, has been purchased from War Assets Administration. The plant is a duplicate of the original Houdry plant which manufactured what is said to be the world's first commercial cracking catalyst in 1940.

Wichita Falls Fire

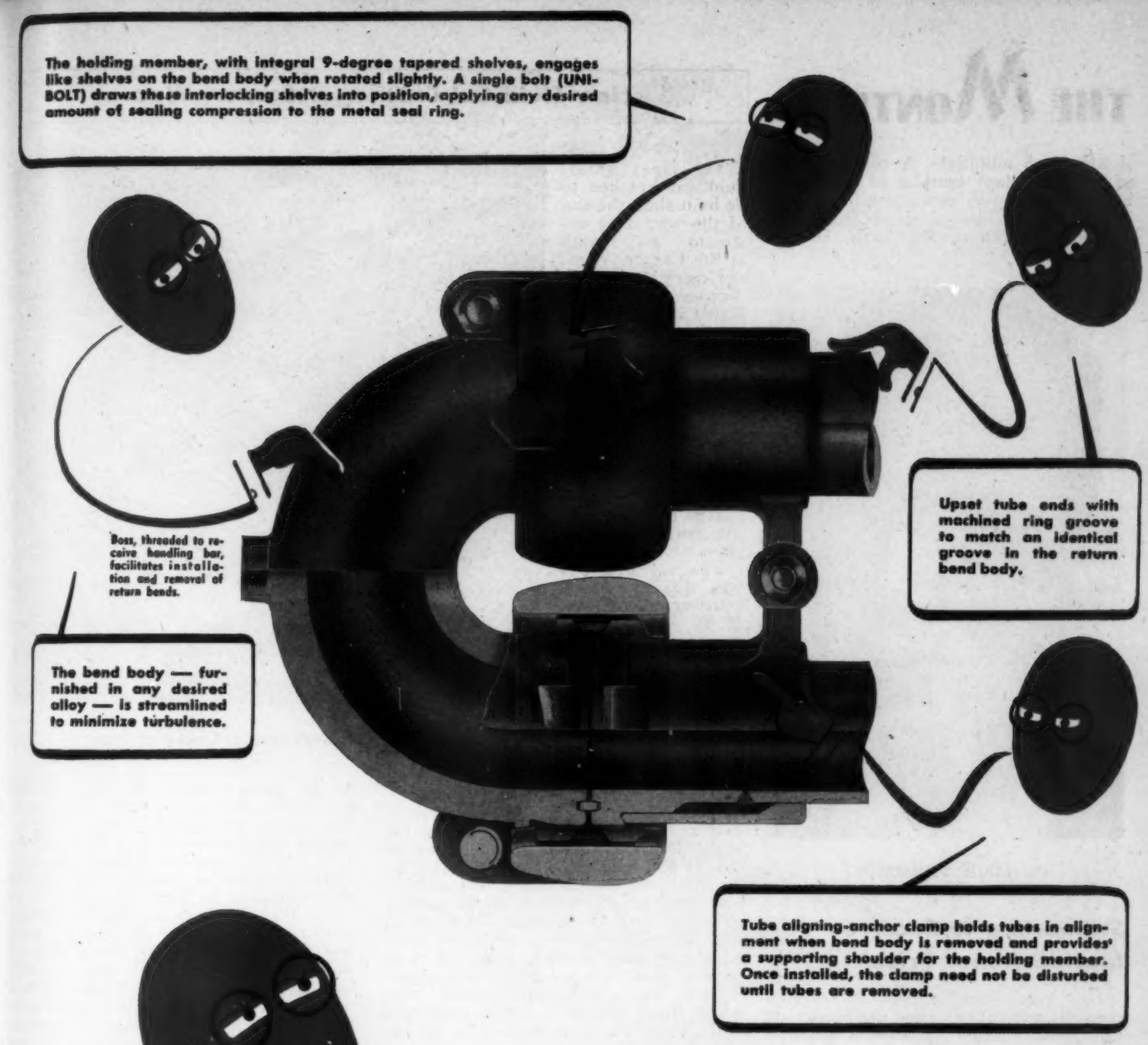
Fire in mid-August caused $150,000 damage to the Panhandle Refining Company plant at Wichita Falls, Texas. The refinery itself suffered little damage, the chief losses being warehouses, gasoline tanks and shops.

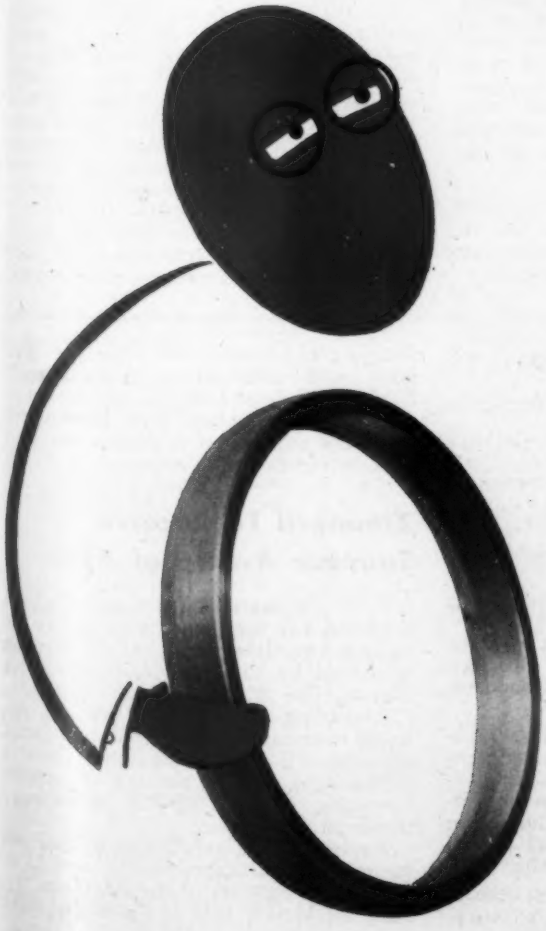
New Hydrocarbon Samples

Seven new NBS standard samples of hydrocarbons recently announced by the National Bureau of Standards bring to 119 the total of these compounds now available for calibrating analytical instruments and apparatus in the research, development, and analytical laboratories of the petroleum, rubber, chemical, and allied industries. Since 1944, when the first of these NBS standard samples of hydrocarbons were made available, 100 additional compounds have been prepared through a cooperative undertaking of the Bureau and the American Petroleum Institute.

The seven new compounds are 2,2,4 Trimethylhexane; 2,3,3-Trimethylhexane; 2,3,5-Trimethylhexane; n-Butylcyclopentane; 1-Hexene; Trans-2-Hexene, and 2-Ethyl-1-butene.

Price for a sample of each compound


The holding member, with integral 9-degree tapered shelves, engages like shelves on the bend body when rotated slightly. A single bolt (UNIBOLT) draws these interlocking shelves into position, applying any desired amount of sealing compression to the metal seal ring.
Upset tube ends with machined ring groove to match an identical groove in the return bend body.
Boss, threaded to receive handling bar, facilitates installation and removal of return bends.
The bend body — furnished in any desired alloy — is streamlined to minimize turbulence.
Tube aligning-anchor clamp holds tubes in alignment when bend body is removed and provides a supporting shoulder for the holding member. Once installed, the clamp need not be disturbed until tubes are removed.



THE RING'S THE THING

that enables UNIBOLT FURNACE FITTINGS *to seal the lightest gases at extreme temperatures*

The UNIBOLT loose ring joint differs from other ring joints in that it (1) does not employ ring "distortion" to effect a seal, and (2) its seats are machined to extremely close tolerance and the seating load is accurately calculated, utilizing predetermined tube load, seating area and area exposed to pressure in a formula which has been unquestionably proven on furnace outlet temperatures ranging up to 1600 degrees F. and working pressures up to 8000 lbs. psi.

This positive seal is accomplished by tightening a single bolt . . . no rolled-in tubes, no seal welding, no tapered plug closures, no lapping to make a seal, no need for steam in the header boxes. They permit faster "heading-up," replacement of a single tube and returning any return bend body to any two tubes. Completely interchangeable parts assure low-cost maintenance.

For complete details, write for Bulletin R-42.

THORNHILL-CRAVER COMPANY, INC.

HOUSTON UNIBOLT **TEXAS**

THE MONTH...

is $35 for 5 milliliters. A complete list of NBS standard samples of hydrocarbons, together with instruction for ordering, may also be obtained from the National Bureau of Standards, Washington 25, D. C.

DR. LOUIS SCHMERLING

Schmerling to Receive Ipatieff Honor Prize

Dr. Louis Schmerling, a research chemist with Universal Oil Products Company, Chicago, has been selected as the 1947 winner of the Ipatieff Prize, a $3000 prize administered by the American Chemical Society, and awarded every three years for outstanding work in catalysis or high pressure by a chemist under 40 years of age.

The prize, given this year for the first time, is awarded for the postulation, explanation and experimental proof of the mechanism of the catalytic alkylation of paraffinic hydrocarbons by olefins, and the investigation of the catalytic addition of alkyl halides to unsaturated compounds.

Since leaving school Dr. Schmerling has been with Universal. The holder of 42 patents mostly in the field of catalysis, he is active in association and committee work.

Professor Ipatieff will present the award to Dr. Schmerling at a general ACS meeting in New York, September 15th.

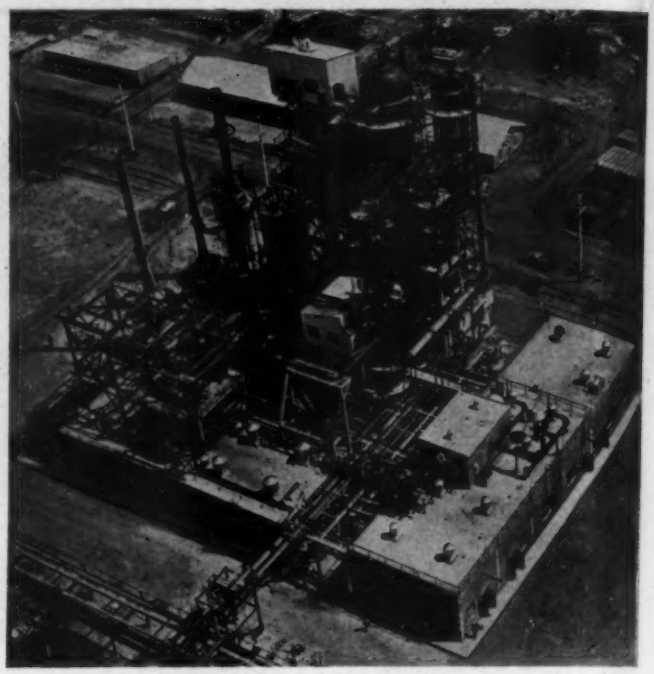
Armistead Offices Moved

George Armistead, Jr., consulting chemical engineer for the petroleum, chemical, and related industries has announced the removal of his offices from 1519 Connecticut Avenue to larger quarters in Suite 712, 1200 Eighteenth Street, Washington 6, D. C.

New Fluid Cat Cracker at Casper, Wyo.

The first small fluid cat cracker to be built since the end of the war went onstream last month at the Casper, Wyo., refinery of The Texas Company. Rated at 4000 barrels per day capacity, the new unit is intended to serve as the focal point of Texaco's expansion and consolidation program at Casper, which officials said will make its Casper Works (10,000 BPD crude charge rate) a model of small refinery planning.

The cat cracker was designed and constructed by The M. W. Kellogg Company, who are also revamping and building catalytic polymerization, naphtha reforming and pressure coking facilities in the same refinery.



The Texas Company's new Cat Cracker at Casper

A new "balanced pressure" design is embodied in the unit. As a result, reactor and regenerator are supported at the same levels; an over-all reduction in height has been effected; and standpipe heights have been reduced. The reduced standpipe heights in turn enable a lower pressure drop to be maintained across the slide valves and so eliminate much of the erosion formerly found in these critical catalyst controlling mechanisms. Piping, too, has been simplified, with short direct runs to all major vessels and with only one expansion joint in the whole unit.

The plot plan, arranged in the shape of an elongated oblong, brings the reactor, regenerator, and precipitator into line in a main structure at the extremity of the battery limits. At the opposite face of the oblong, a second row of vessels brings the fractionator and gas recovery equipment into line. This oblong arrangement, open on all four sides with all big vessels on the outside, enabled each vessel to be lifted into position as soon as it arrived on the job site without interfering with other erection proceeding simultaneously. The installation of piping, structural steel and internal auxiliary vessels was not delayed by this outside arrangement of the big vessels, nor did each large vessel in position interfere with the installation of its neighbor. As a result, the unit is a model of construction efficiency and clearly shows the effect of plot plan and vessel arrangement on construction costs, construction time and ease of maintenance.

Contract Let By Conoco For Refinery at Billings

Completion of plans by Continental Oil Company for construction of a 7500-barrell daily oil refinery at Billings, Mont., to cost approximately $8.5 million have been announced by H. G. Osborn, vice president in charge of manufacturing.

Contract for construction has been signed with the Jones & Laughlin Supply Company, Tulsa, with plant work to start in the spring of 1948, although railroad sidings, temporary warehouses, etc., will be completed this year.

The plant will combine the most modern processes, including catalytic cracking, catalytic desulfurization, polymerization, and solvent extraction of asphalt, Osborn said. It will manufacture a high-octane gasoline and a full line of burning fuels and road asphalts.

The 100-acre tract is at the southeast edge of Billings. In addition to the refinery, construction will include a tank farm with storage for approximately 700,000 barrels of crude oil and products.

The Billings plant will increase to eight the number of refineries operated by Continental Oil Company.

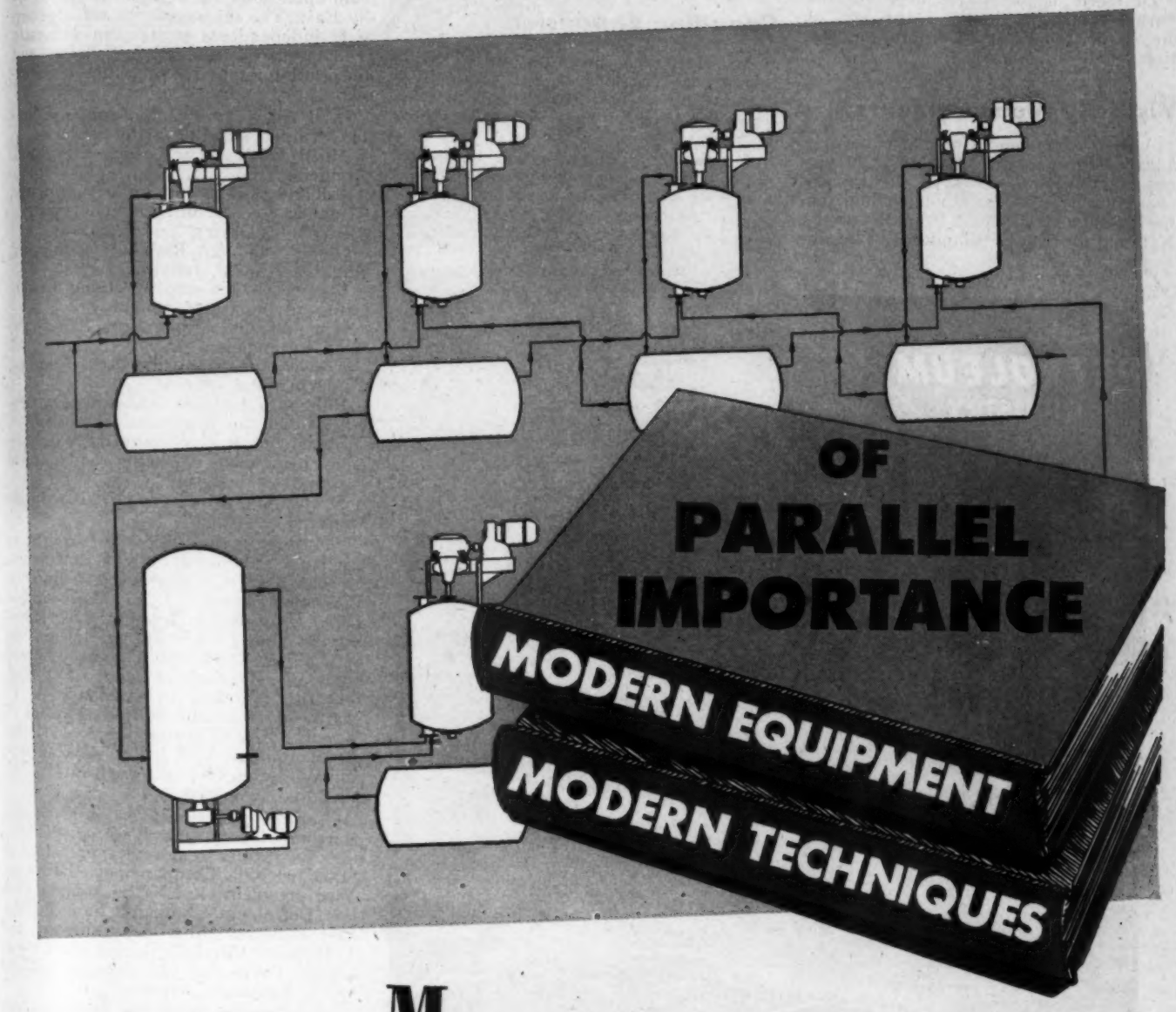
Zimmerli To Receive Sauveur Award of ASM

F. P. Zimmerli, Detroit metallurgical engineer, has been elected to receive the highest award for technical achievement conferred by the American Society for Metals, The Albert Sauveur Award.

According to W. H. Eisenman, national secretary of the ASM, the award to Zimmerli is "for his basic research in the field of shot peening to increase favorable stresses in the surfaces of metal parts."

Award of the scroll and plaque will be made in Chicago on October 23 at the annual banquet of the American Society for Metals, held as a principal event

Turbo-Topics



Other General American Equipment

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Crude • Gasoline • Propane
Butane • Chlorine • Acid
Blending • Mixing • Water

TOWERS
Absorber • Flash
Bubble • Pressure
Vacuum • Fractionating

DEWAXING FILTERS
STACKS • BINS
STEEL & ALLOY
PLATE FABRICATION
WIGGINS ROOFS
TURBO-MIXERS

MODERN techniques in the refining of high sulphur crudes require modern equipment.

The Turbo-Treater and the Turbo-Oxidizer are producing excellent results in the countercurrent removal of mercaptans from hydrocarbons and the oxidation and extraction of the spent treating solution.

The above flow sheet is typical.

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GATX GENERAL AMERICAN

THE MONTH . . .

of the National Metal Congress and Exposition.

Zimmerli is chief engineer of the Barnes-Gibson-Raymond Division of the Associated Spring Corporation, Detroit.

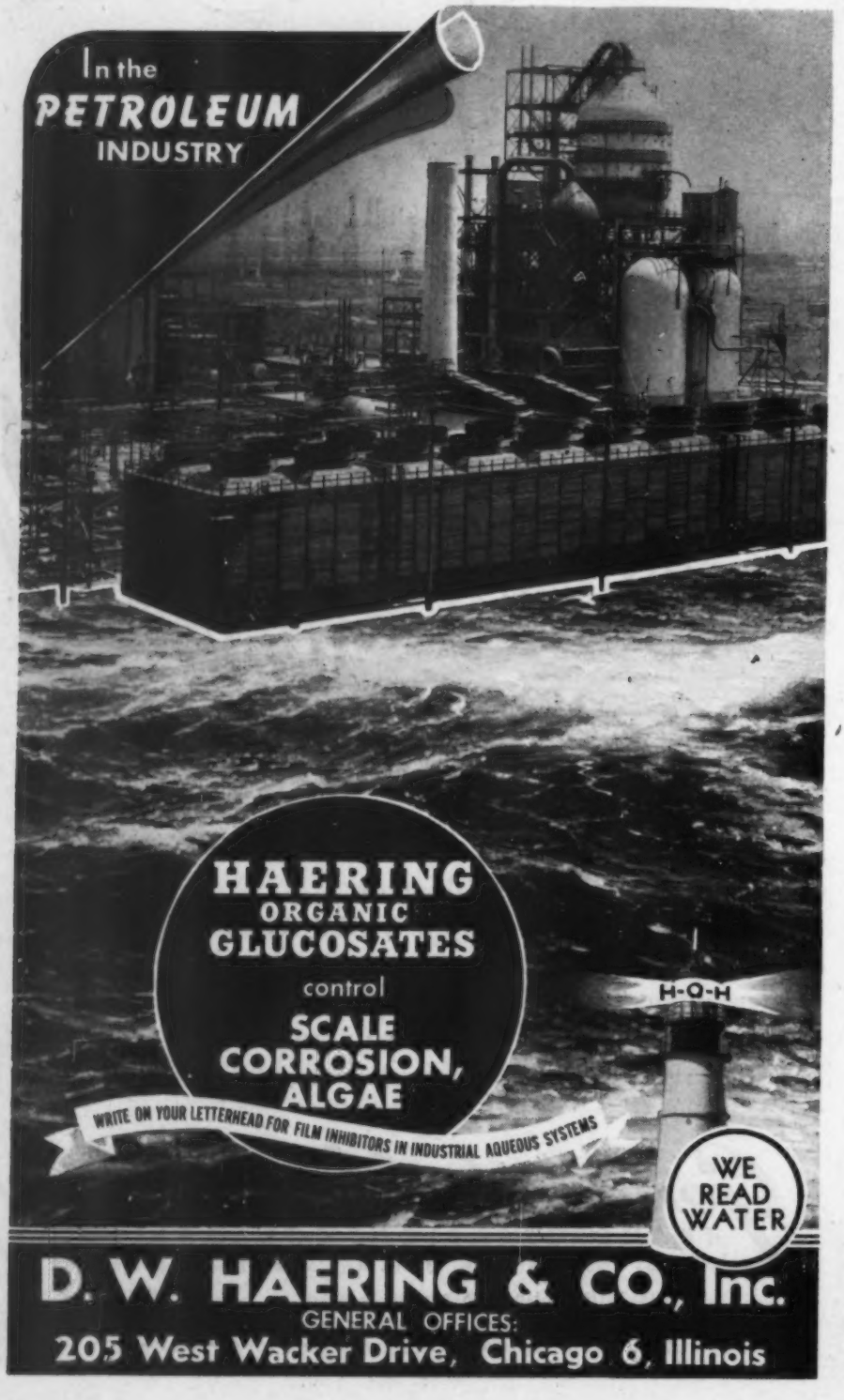
Viscosity Measurements

A new electronic timer, particularly adapted for use with a falling-ball viscosimeter in the study of the rapidly changing viscosity of an opaque fluid, has been designed by P. J. Franklin of the National Bureau of Standards. The device consists of pulse sharpening and trigger circuits, and the passage of the ball through two coils around the viscosimeter tube is used to trigger a radio frequency oscillator, starting and stopping a timing device.

Canadian Expansion

An expansion program which will increase its over-all Canadian productive capacity by at least 100 percent in two years has been announced by Monsanto (Canada) Limited.

A substantial increase will be made in productive capacity for phenolic resins which are produced at Montreal together with polystyrene. Other expansion has not been specifically outlined.



Independents Organize For Foreign Operations

American-Independent Oil Company, a $100 million corporation, was organized last month to engage in foreign petroleum operations, particularly in the Middle East. The incorporators are a group of 11 independents engaged in domestic production, transportation, refining and distribution of petroleum, these including:

J. S. Abercrombie, Houston, producing, drilling, gasoline plant operation.

Allied Oil Company, Inc., Cleveland, producing.

Ashland Oil & Refining Company, Ashland, Ky., an integrated company.

Ralph K. Davies, San Francisco.

Globe Oil & Refining Company, Wichita, Kansas, refining.

Hancock Oil Company, Long Beach, Calif., an integrated company.

Honolulu Oil Corporation, San Francisco, producing.

Los Nietos Company, Los Angeles, producing and refining.

Phillips Petroleum Company, Bartlesville, Okla., an integrated company.

Signal Oil & Gas Company, Los Angeles, producing, marketing and natural gasoline manufacture.

Sunray Oil Corporation, Tulsa, an integrated company.

The directors of the new corporation are K. S. Adams of Phillips Petroleum, Vernon Barrett of Los Nietos Company, Jack Blalock with J. S. Abercrombie, L. A. Cranson of Honolulu Oil, Ralph Davies, Don Emery and Paul Endacott of Phillips, Russell H. Green of Signal, John W. Hancock of Hancock Oil, J. Howard Marshall of Ashland, A. C. Mattei of Honolulu, Sam N. Mosher of Signal, I. A. O'Shaughnessy of Globe, Frank Phillips, Will J. Reid of Hancock, W. W. Vandeveer of Allied and C. H. Wright of Sunray.

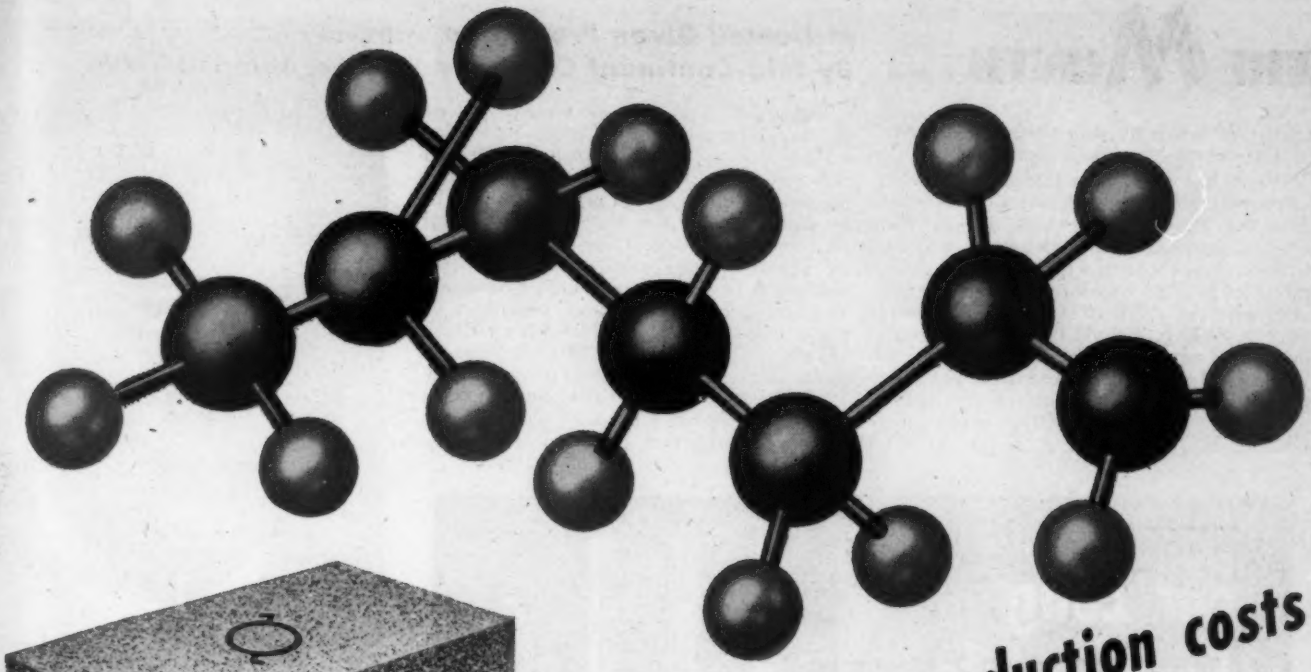
President of AIOC is Ralph K. Davies, wartime deputy petroleum administrator and former senior vice president of Standard Oil Company of California. Vice presidents are K. S. Adams, Phillips Petroleum Company, Sam B. Mosher of Signal Oil & Gas Company, and J. Howard Marshall, former chief counsel for PAW and president of Ashland Oil & Refining Company.

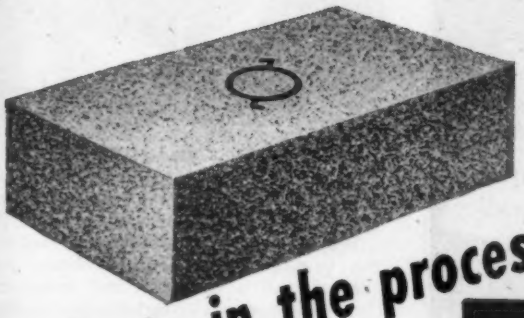
A delegation from the new company will depart shortly for the Near East to further discussions already begun with rulers of the "neutral zone" now administered jointly by the rulers of Kuwait and Saudi Arabia. The independent group also is interested in oil development possibilities in the kingdom of Yemen, which lies on the Red Sea at the southwest corner of the Arabian Peninsula.

Headquarters of the new company, which is incorporated in Delaware, will be in Washington, D. C., and San Francisco.

Shea Named Ethyl Head

Edward L. Shea has been named president of Ethyl Corporation to succeed Earle W. Webb, who becomes chairman of the board. Shea is former president of Tide Water Oil Company, executive vice president of Tide Water Associated Oil Company and a director of the American Petroleum Institute. He was associated with Tide Water for 23 years





Catalysts in the process of lowering production costs

B&W INSULATING FIREBRICK + PROCESS FURNACES = Low Maintenance; Increased Production through quicker heating; Improved Quality through closer temperature control; Lower Fuel Bills = LOWER OVERALL PRODUCTION COSTS

"Reduced production costs"—this is the continuing theme of service reports from the many chemical process furnaces lined with B&W Insulating Firebrick.

Because of their low heat-storage and high insulating value, lightweight B&W IFB respond quickly to temperature changes, substantially cut heat losses. Increased production, improved quality, lower fuel bills are the direct results. And because of their superior durability in service, B&W Insulating Firebrick provide all of these advantages with extremely low maintenance cost.

Your local B&W Refractories Engineer will be glad to discuss with you the question of increasing the efficiency of your furnaces through the use of B&W IFB.

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R-278

THE MONTH . . .

until 1939 when he was elected president of The North American Company.

Webb has been associated with Ethyl Corporation since its inception and president for 22 years. He was one of the original directors of General Motors Chemical Company, which was incorporated in 1923 to handle the manufacture and sale of "Ethyl" antiknock compound. When Ethyl Corporation was organized under the joint ownership of General Motors and Standard Oil Company (New Jersey), Webb was elected president April 21, 1925, succeeding Charles F. Kettering.

McDowell Given Promotion By Mid-Continent Company

Robert W. McDowell, vice president in charge of sales, Mid-Continent Petroleum Corporation, last month was elected executive vice president, a newly created position. He began his oil career in 1918 as stenographer for the Producers and Refiners Corporation in Tulsa. In 1924 he became vice president and general manager of Hawkeye Oil Company, Waterloo, Iowa, and later president of the company when it merged with Black Hawk Oil Company. Mid-Continent's purchase of Black Hawk properties in 1927 brought him into that organization and he specialized in sales and marketing, becoming vice president in charge of sales in 1930 when he was only 34 years old. He became a director in 1944.

He is a director and vice president of the Western Petroleum Refiners Association and a director and member of the API's general marketing committee.

ROBERT W. McDOWELL

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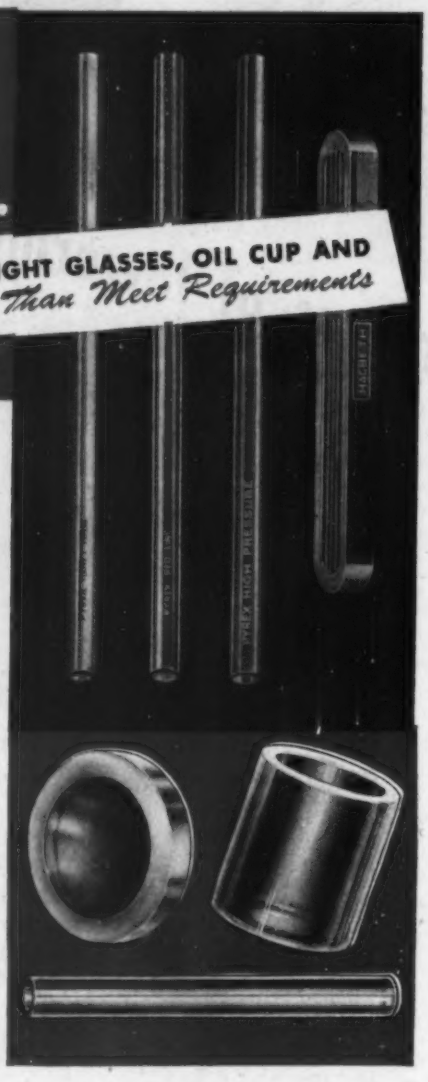
CORNING GAUGE GLASSES, SIGHT GLASSES, OIL CUP AND LUBRICATOR GLASSES *More Than Meet Requirements*



For trouble-free service, always specify Corning products when you need gauge glasses, sight glasses, oil cup and lubricator glasses. Made to exacting standards and tested for pressure and temperature shock, you can be sure that the product you select will stand up.

Gauge Glasses: PYREX and CORNING brand tubular gauge glasses and Macbeth brand flat gauge glasses provide good visibility over prolonged periods, and even under severe conditions.

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Oil Cup and Lubricator Glasses: PYREX and CORNING brand products give you visibility plus long life.

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BRAND

Companies Responding to Public Relations Program

More than 750,000 copies of editorial material supporting and promoting the oil industry and its nationwide program of public relations have been ordered by oil companies and trade associations for employe and public distribution, a report covering progress for the first seven months showed recently.

More than 1000 companies and 40 trade associations are actively supporting the work being carried on through the twelve district committees on which more than 1500 men representing all phases of the oil business are serving. It reveals that more than 200 district, state, area and community meetings have been held thus far to promote the program.

Within the district committees, state and area committees are now organized and are at work presenting the program at community levels. It is the purpose of these "front-line" committees to clarify facts, remove misconceptions and equip the industry itself to utilize its facilities for producing public understanding.

Petroleum Chemicals School By Du Pont for Post Grads

A service school in petroleum chemicals, on the post-graduate level, has been established as the Du Pont Company's first step in a greatly enlarged research, sales and technical program in that field.

The course in this "industrial college" combines practical and theoretical aspects and extends over many months, the length depending on the subject matter covered and the specialization.

The technical background of the men enrolled embraces a wide range of college study in chemical, automotive,

THE MONTH...

mechanical and petroleum engineering, plus a substantial amount of specialized practical experience in these fields.

After orientation at the Du Pont headquarters in Wilmington, the students spend several weeks in the Petroleum Laboratory at the Chambers Works, Deepwater Point, N. J., for study of lubricating oils and petroleum additives. They are then transferred to the Petroleum Engineering Laboratory, also at the Chambers Works, principally for study of engines, fuels, practical application of additives and their uses, and how anti-knock mixtures react in fuels.

The students then specialize in various lines. These specialized courses take about five months each.

At the end of the course, the students are assigned to districts. Late this autumn the first group of students will return to Wilmington for a refresher course.

Baxter Heads Deep Rock

C. Kenneth Baxter has been elected chairman of the board and president of Deep Rock Oil Corporation. Orville O. Kerr has been named executive vice president.

Baxter has been a Deep Rock director since 1941.

Gill Company Announces Acquisition of Ragatz

The California firm of J. B. Gill Company recently announced an association with Edw. G. Ragatz, absorption process specialist, for the purpose of rendering complete processing, engineering and construction service in the field of natural gasoline recovery.

Ragatz has been actively identified with natural gasoline for the past 20 years, and is nationally recognized for his many technical contributions to the industry. During this period he has initiated numerous advances in plant proc-

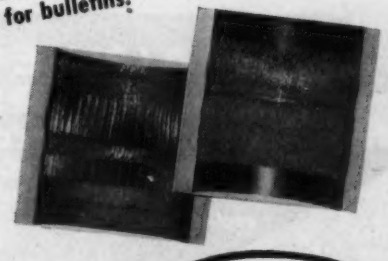
EDW. G. RAGATZ

● FASTER TUBE CLEANING ! ● FASTER GAGING ! ● FAR LESS DOWN TIME

The New Form Cutters employed in all Airetool Tube Cleaners do a faster, more thorough tube cleaning job WITHOUT TRACKING or TUBE DAMAGE! And when tubes are really clean, accurate gaging can be done in half the usual time. Thus "down-time" is cut to a minimum . . . and efficiency goes way up — resulting in a greater flexibility of operation.

Indeed, Airetool Tube Cleaners make the job easier . . . SAVE TIME! . . . there's an Airetool Tube Cleaner and expander to meet every refinery requirement. Write for bulletins.

the photograph at right shows a section of furnace tube cleaned with ordinary cutters . . . and the same section, at extreme right, after being cleaned with Airetool's New Form Cutters.



I CAN ALWAYS TELL WHEN TUBES HAVE BEEN CLEANED WITH AIRETOOL'S NEW FORM CUTTERS! THEY'RE REALLY CLEAN. AND YOU CAN GAGE THEM IN HALF THE USUAL TIME!

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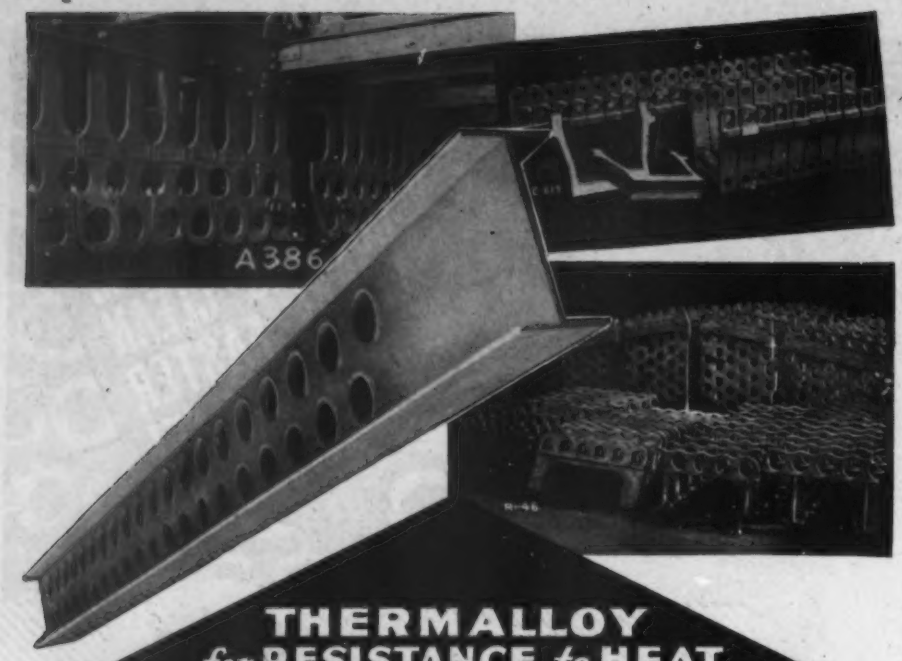

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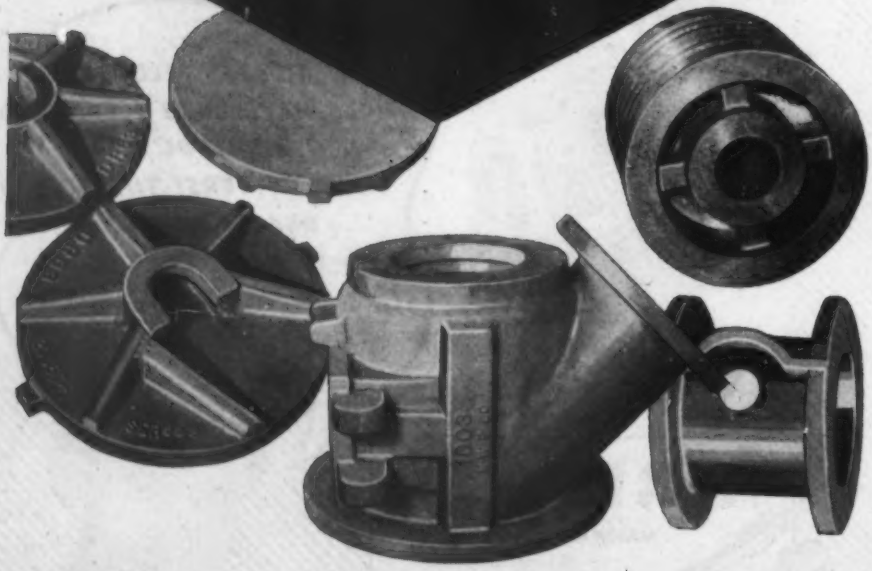
for RESISTANCE *to* HEAT

THERMALLOY heat resistant castings are serving many large refineries. The high quality of THERMALLOY for rigid refinery specifications is assured by 25 years of alloy manufacture.

X-RAY *PILOTED*
CASTINGS

STAINLESS STEEL
and NI-RESIST *for*
RESISTANCE *to* CORROSION

STAINLESS STEEL and NI-RESIST castings are produced to the highest quality inspection standards for all corrosive applications.



AMERICAN Brake Shoe COMPANY
ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO.

THE MONTH...

ess and engineering designs, while contributing extensively to the technical literature.

His latest technical contribution is the "Straight-Line Chart" method of evaluating absorber performance.

The Gill organization is under the direction of Glen J. Gill since the retirement of its founder, J. B. Gill, a year ago. Harry R. Marsh is the company's chief engineer.

Commodity Division for National Standards Bureau

Consolidation of two divisions of the National Bureau of Standards—Commercial Standards and Simplified Practice—into a single division called Commodity Standards has been announced by Dr. E. U. Condon, Director of the Bureau.

The new Commodity Standards Division will continue the Bureau's coordinating role in the development of voluntary simplified practice recommendations and commercial standards with industrial and technical groups. In addition, the division will be responsible for coordinating Bureau work for the Federal Specifications Board. Edwin W. Ely, former chief of the Simplified Practice Divisions has been appointed as chief of the division and F. W. Reynolds, former acting chief of Commercial Standards, as assistant chief.

As the official standardizing agency of the Federal Government, the Bureau works in close cooperation with non-federal agencies doing similar work.

Massive German Machines To Be Used in Synthesis

Considerable equipment used by Germans in their wartime production of synthetic liquid fuels have been consigned to the Missouri Ordnance Works near Louisiana, Mo., where the Bureau of Mines is readying a plant for obtaining oil and gasoline from coal. Samples of German-made hydrogenation catalysts in some 600 drums also have been brought to the U. S. and will be used in design work and experiments.

A hydrogenation-process converter, weighing 130 tons is included, as are a gas synthesis process converter, a "wickelofen" type heat exchanger, two coal paste injectors, a hairpin bend form paste preheater, a Linde-Frankl oxygen plant unit with capacity of 25,000 cubic feet of oxygen per hour, DeLaval centrifuge and special purpose valves, fittings, lens gaskets, and instruments.

Coal Gasification Plant Contract Award Announced

The research and development division of Pittsburgh Consolidation Coal Company has awarded contract for design and construction of its coal gasification pilot plant to chemical plants division of Blaw-Knox Company, work to start this year.

This pilot plant, sponsored jointly by Standard Oil Development Company and Pittsburgh Consolidation, is to

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It takes more than a plant to provide dependable, reliable drill pipe that can stand the gaff of drilling. It requires experience and "know-how" on the part of the men who operate that factory.

For dependable power that can do the job . . . drilling, pipe-lines, refining and pumping . . . look to your local Utility Electric Power Company. They not only have the facilities, but their power plants are manned by technically trained personnel that can better meet your needs for power. And the cost . . . it's rock bottom.

Call the Power Engineer of your local Utility Electric Power Company and find out if you are getting the most for your power dollar. He will be glad to analyze any of your power needs and make suitable recommendations . . . at no cost or obligation.

Use Utility Electric Power!

PETROLEUM ELECTRIC POWER ASSOCIATION

Box 1498, Oklahoma City, Oklahoma

THE MONTH...

ascertain whether a practical and commercial process can be found for making synthesis gas, a first step in producing synthetic fuel from coal.

Present estimates indicate the cost of the pilot plant will be in excess of $500,000. The $500,000 pilot plant, to be located at Library, near the coal company's research center, will be a completely integrated and continuous processing unit, the heart of which will be a synthesis gas generator, a cylindrical column supported by a steel structure about 80 feet high. It will generate approximately 1,000,000 cubic feet of synthesis gas per day.

Coal Gasification Work

Dr. D. Leigh Fowler, Jr., recently of Corning, N. Y., has been named manager of the patent department of the research and development division of Pittsburgh Consolidated Coal Company.

W. D. McElroy formerly of Philadelphia has been named manager of the division's development department and will be in charge of all pilot plant operations in the coal gasification work.

Monsanto Appointments For the Month Listed

Monsanto Chemical Company personnel announcements during the past month include:

Promotion of Ralph J. Holtschlag and Dr. Robert E. Howard to group leaders in the St. Louis Research Department of the Organic Chemicals Division.

Herbert O. Tittel, maintenance superintendent of the plant at Anniston, Ala., named production superintendent of the Trenton, Mich., plant.

In the company's research laboratories at Dayton, Ohio, Dr. Robert A. Staniforth appointed chief of the chemistry section, Dr. Raymond Davis, Jr., promoted to the position of group leader in physics and Dr. Wilson H. Power promoted to group leader of fundamental research.

Elmer P. Wheeler appointed director of a newly-formed section of Industrial Hygiene in the medical department, to be in charge of industrial hygiene in all Monsanto plants in the U. S. Section headquarters will be in St. Louis.

Atkinson and Caldwell Join Phillips Petroleum

Phillips Petroleum Company, Bartlesville, Okla., last month announced two additions to its staff:

Blake M. Caldwell, formerly general manager of Emsco Derrick and Equipment Company's Dallas plant, has joined the mechanical equipment division of the Chemical Engineering Department of Phillips. He is a 1929 graduate of Texas A. & M. College.

Dr. Robert G. Atkinson, formerly with Hydrocarbon Research, Inc., has accepted a position as a chemical engineer in the Chemical Engineering Department of Phillips. A Ph.D. (1934) in petroleum refining from the University of Pittsburgh, he was associated with Shamrock Oil and Gas Corporation, Amarillo, Texas, as technical adviser for nine years before joining Hydrocarbon Research. He is well known in the natural gasoline industry.

THOMAS P. SIMPSON

Simpson Heads Research Work For Socony Vacuum

Thomas Patrick Simpson, for many years a chemical engineer with General Petroleum Corporation in Los Angeles, has been named director of the Socony-Vacuum Oil Company's research and development laboratories at Paulsboro, N. J.

Simpson, who took an important role in the development of the Thermofor catalytic cracking process, joined General Petroleum as a chemical engineer in 1923. In 1933 he was named supervisor of Process Laboratories and two years later, was transferred to Socony-Vacuum as chief development engineer. In 1944 he was appointed assistant director of research.

Specials to API

Special trains to the API annual meeting, November 10-13 in Chicago, will be operated from Houston, Dallas and Tulsa.

Houston's will leave at 7 p.m. Saturday, November 8, arriving in Chicago at 9 p.m. Sunday, and returning will depart at 9:15 p.m. Thursday, the Missouri Pacific Lines making arrangements.

The Dallas train, an M-K-T special, will leave at 4:15 p.m. Saturday and arrive at 2 p.m. Sunday in Chicago. Returning the train will depart at 11:45 a.m. Thursday, November 13.

Tulsa's schedule was not available early this month.

Sohio Contract Awarded

Catalytic Construction Company, subsidiary of Houdry Process Corporation, has been given a maintenance contract for the case repair and catalyst-change for Standard Oil Company (Ohio) Cleveland. The unit, which went on stream June, 1944, is a 20,000 barrels daily catalytic cracker, consisting of nine reactor cases, at Standard's No. 1, Cleveland refinery.

Humble's Scientific Lecture Program Gets Under Way

Dr. E. R. Gilliland, of the Massachusetts Institute of Technology, last month conducted the second annual program of "Humble Lectures in Science." The lectures were inaugurated by Humble Oil & Refining Company last year for the benefit of its technical and research personnel at Baytown refinery.

Dr. Gilliland's two weeks course expanded and enlarged on his subject for last year's lectures: "Transference of Processes from Small to Large Scale." He was followed by Professor H. A. Laitinen, of University of Illinois, who on September 2 started a three weeks course of lectures on "Physical Chemical Problems of Analytical Chemistry."

Professor A. P. Colburn, assistant to the president and advisor on research at the University of Delaware, will conduct a two weeks series of lectures on "Special Topics in Distillation" early in February, 1948. He will be followed in the spring by Professor Richard T. Arnold, of the chemistry department of the University of Minnesota, who will discuss "Special Topics in Organic Chemistry."

Professor Joel H. Hildebrand, of the University of California, will appear on Humble's program during the latter half of June, 1948, lecturing on Thermodynamics.

The 1947-48 program will be closed out with two two-weeks courses in August and September, 1948, by Professor F. A. Matsen of the University of Texas, whose subject will be physical chemistry.

Addressees Are Scheduled For Chemical Conferences

Addresses to be given during the Pacific Industrial Conferences to be held in San Francisco's Civic Auditorium concurrently with the Pacific Chemical Exposition, October 21-25 include:

"Process for Manufacture of Gasoline by Polymerizing Propene and Butenes," Lloyd F. Brooke, California Research Corporation.

"Aromatics from Petroleum," Dr. George L. Parkhurst, Oronite Chemical Company.

"The Fluidized Solids Technique Applications in the petroleum Industry, E. V. Murphree, executive vice president, Standard Oil Development Company.

"Chemistry and Engineering in the Oil Industry," Dr. Gustav Egloff, Universial Oil Products Company, Chicago.

Movie analyzing action on bubble trays accompanied by talk by Arthur M. Whistler, process consultant for C. F. Braun & Company.

"Stuffing Boxless Pumps," Alaxdar Hollander, California Institute of Technology; Walter L. Dorward and J. B. Van Horn, Byron Jackson Company.

"An Improved Apparatus for Molecular Weight Determinations," R. Matteson, California Research Corporation.

New Motor Oil Said Good for 30,000 Miles

Union Oil Company of California last month introduced its new motor oil, the advertisements of which emphasized a test wherein four new cars were operated continuously for 30,000 miles without an oil change. Union said that after this test the engines were still in perfect conditions with no sludge or varnish found in the crankcase.

This oil, which sells 10 cents higher per quart than the best "regular" grades, actually is the same that Union has marketed to fleet operators for the past year. It is said to contain larger doses of oxidation inhibitors, detergents and anti-acid compounds than Union's regu-

THE MONTH...

lar oil. The company says its new oil is chiefly valuable to motorists with new cars or older cars with recently overhauled engines.

Indiana Standard Workers Are Given Safety Awards

A certificate of honor has been awarded to the manufacturing department of Standard Oil Company (Indiana) by the Joseph A. Holmes Safety Association "for reducing the accident-frequency rate for 1946 to 37 percent below that for 1945 with the employment of 10,948 employes working 20,916,822 man-hours." The accident-frequency rate for the manufacturing department was 1.15 per million man-hours worked in 1946 and 1.84 in 1945.

This was the first Holmes safety award presented to all employes of Standard's manufacturing department at the company's six refineries at Casper and Greybull, Wyo.; Neodesha, Kan.; Sugar Creek, Mo.; Whiting, Ind.; and Wood River, Ill. Three such awards had previously been given to all employes at Whiting, all employes at Wood River, and mechanical department employes at Whiting.

Texas City Damages Asked of Government

Texas City Terminal Railway Company has filed a suit against the U. S. Government for $8 million in connection with last April's explosion and fire. Terminal officers charged negligence on the part of the government for misleading labels (fertilizer) on ammonium nitrate without proper warning of the dangerous nature of the materials.

Monsanto Men to Study Management at Harvard

Leaves of absence to attend the advanced management program of the Harvard University Graduate School of Business Administration have been awarded R. S. Wobus and William M. Russell of Monsanto Chemical Company. Wobus is manager of Monsanto's Norfolk, Va., plant, and Russell, branch manager, Organic Chemicals Division, Detroit territory.

Previously management leaves of absence had been experimentally awarded Robert U. Haslanger, assistant to William M. Rand, Monsanto's president, and Alfred W. Long, comptroller of the company's Plastics Division at Springfield, Mass.

Jefferson Plant Progress

Operation of certain portions of the new Jefferson Chemical Company, Inc., plant at Port Neches started in August, A. A. Triska, plant manager, announced. Start up of other units will follow as fast as construction permits.

Material deliveries, heretofore the main bottleneck, has been overcome, and the only factor now delaying construction is shortage of skilled construction workers.

PAUL M. WADDILL

Waddill Named Liaison For Phillip's Refining

Paul M. Waddill, manager of licensee service section of Phillips Petroleum Company's chemical engineering department, has been appointed to act as liaison for the company's refining department with other refiners. Waddill, who will be available for consultation on the company's refinery engineering and operating problems, is a graduate of Oklahoma A. & M. with a B.S. degree in Chemical Engineering, 1931. He joined Phillips Petroleum Company in July, 1934, at the Borger, Texas, refinery as chemist, later working as engineer, process engineer, process foreman and manufacturing superintendent. From 1938 to 1943 he was assistant superintendent at Phillips Petroleum Company, Okmulgee, Okla., refinery. In 1943 he was made assistant manager of the process engineering section of the chemical products department and in 1946 he became manager of the licensee service section of the chemical engineering department.

Engineering Companies Organize Association

The need for the accumulation, distribution and interchange of information among engineering companies in the construction of oil, refining, chemical and steel plants has resulted in the formation of the National Constructors Association.

G. F. Hayes, director of construction for W. M. Kellogg Company, was elected president, with R. F. Carter, general superintendent of Lummus Company as vice president. C. B. Bronson was named secretary-treasurer.

Headquarters for the new organization is at 277 Broadway, New York. Among the members are Stone & Webster Engineering Corporation, Foster Wheeler Corporation, Koppers Company, Inc., Chemical Construction Company, and Garver Tank & Manufacturing Company.

WAA Preference to Buyers Supplying Army and Navy

Adoption of a new policy restricting sales of the remaining nine 100-octane aviation gasoline refineries still held by the government to buyers who promise to put the facilities into production of critically-needed military products instead of converting the refinery to other items was announced recently by the War Assets Administration.

The action was the result of the conference held the previous week of industry leaders with the Army, Navy and Air Forces on the problems of the Army and Navy in meeting its needs for aviation gasoline of all grades and Navy diesel oil. The WAA disclosed its action in a letter to the Army-Navy Petroleum Board in response to the board's appeal for cooperation of all agencies and industry in meeting the supply problem.

The Army and Navy have been contacted by parties interested in purchasing some of these facilities with offers to produce aviation gasoline for the military services, providing these parties are successful in obtaining the refineries in question.

The board, which said the appeal carried the concurrence of the Secretary of the Navy and Secretary of War, pointed out that this procedure not only would benefit the armed services in obtaining additional products but would insure prospective purchasers of the surplus facilities of an outlet for their products.

The nine remaining gasoline surplus refineries include:

Texas—Two in Texas City, one at Pasadena, one at Houston and one at Corpus Christi.

Oklahoma—One at Ponca City.

California—One three miles west of Bakersfield and one at Richmond.

Kentucky—One at Catlettsburg.

U. S. Sells Refinery At Richmond to Standard

Sale of the government's $21 million high-octane gasoline refinery at Richmond, Calif., to Standard Oil Company of California for $6 million has been announced by WAA.

Standard of California was the only bidder for the plant. It will pay 20 percent of the bid price and the balance in 90 months.

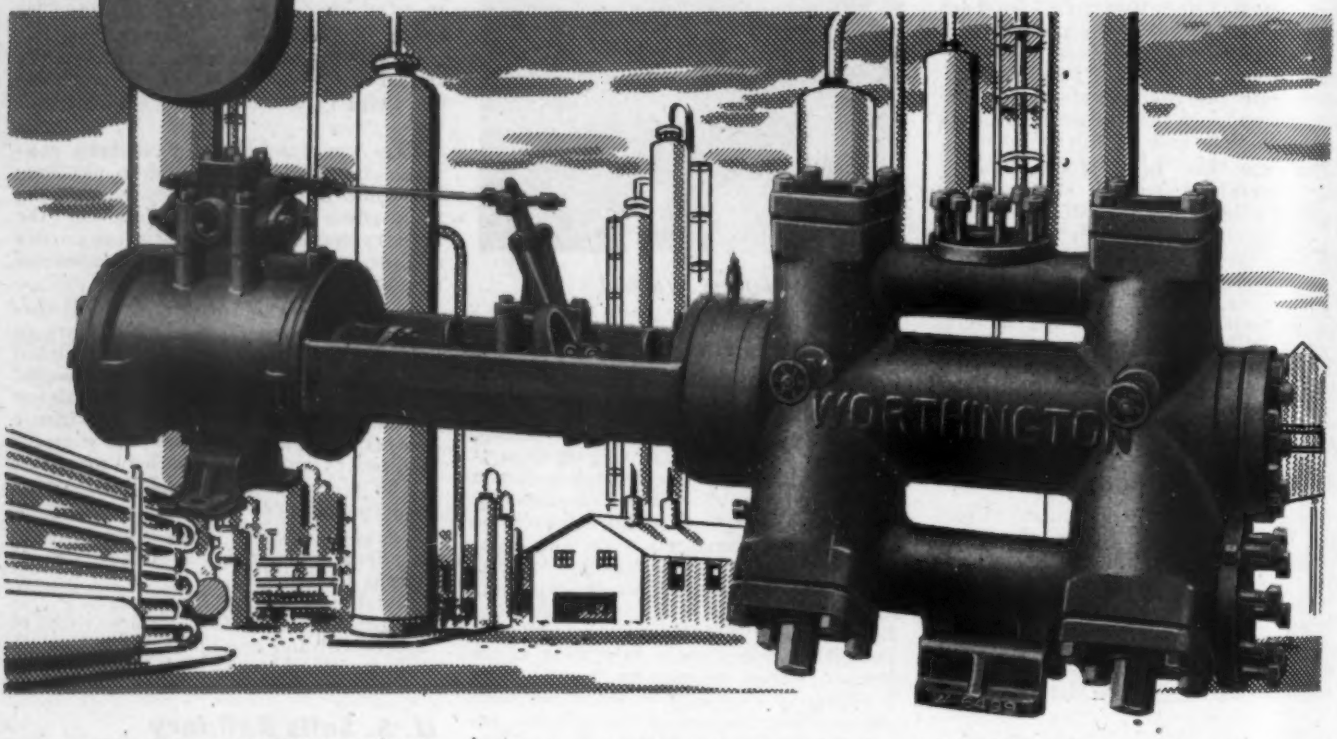
Included in the sale are two Thermofor catalytic cracking units with separate gas reconversion units; one HF alkylation unit, one isomerization unit, a butane-pentane unit and a distillation unit together with numerous other facilities. WAA said each of the cracking units was designed to handle 14,000 barrels daily of gasoil but because of improvements each is now rated at 20,000 barrels daily.

Stone Plant Sold

The Stone Oil Company properties, including a 7500-barrel-daily refinery at Texas City, Texas, have been sold to Pan American Refining Corporation. The plant will continue to operate under the Stone name with P. J. Sweeney, vice president and general manager of Pan American as president. Dr. H. R. Snow will be vice president; Albert Arlie, secretary-treasurer; E. G. Barrett, assistant

7 WAYS TO MORE PROFITABLE PUMPING

...through the Worthington HiVol



The Worthington HiVol horizontal simplex direct-acting piston pump handles highly volatile liquids at high volumetric efficiencies. Incorporating the most advanced engineering in refinery pumps, the HiVol gives you seven features that cut pumping costs:

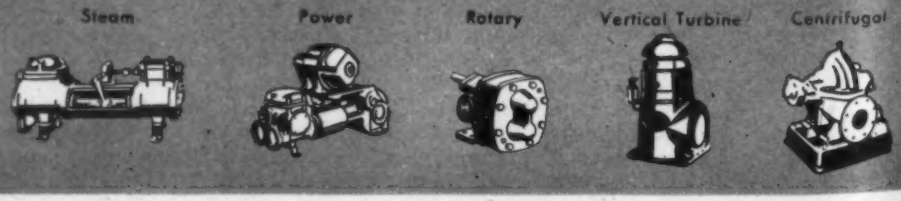
- Can be operated by direct gas pressure from the well.
- Close clearances without passage restriction . . . extra long liquid piston reduces clearance at end of stroke . . . suction and discharge valves located for liquid flow direction through valve and into pulsation chamber.
- Direct upward flow . . . the natural path for gas.
- Simplex steam end prevents short stroking . . . permits full displacement even under gassing conditions.
- Top grade materials for long service life, low maintenance: two-piece piston rods of stainless steel on liquid end; removable NiResist liquid cylinder liners; bakelite liquid piston packing.
- Priming valves relieve vapor-binding.
- Valve pots adaptable to disc, wing or semi-spherical valves.

Bulletin W-113-B32 proves that *there's more worth in Worthington*. *Worthington Pump and Machinery Corporation, Reciprocating Pump Division, Harrison, New Jersey.*

WORTHINGTON

P7-9

THE WORLD'S LARGEST MANUFACTURER OF PUMPS



treasurer, and Walter Herget, plant manager.

Stone Oil Company was organized in 1930 by R. W. and H. M. Stone, principal stockholders when the sale was made to Pan American.

Gasoline Plant Upped

Shell Oil Company and Coltexo Corporation have arranged for construction of their jointly-owned Wasson No. 2 gasoline plant, work to start as soon as materials on order can be delivered. Completion is set for early 1948. The extension is designed to process an additional 24,000 mcf daily from the Wasson field. Present capacity of the two jointly-owned plants there now is 75,000 mcf.

Dow Chlorine Plant

Tellepsen Construction Company has been awarded a contract by Dow Chemical Company for a $4.5 million chlorine plant to be built at Freeport, Texas. Slated to have started in February, the project has been delayed on account of labor and material shortages. Work which will take about a year to complete includes foundation work, piping, buildings and chemical equipment placement.

Refining Modernization and New Units Costing $9 Billion Are Declared Needed

The industry must expend $3 billion yearly during the next three years on modernization and new refining facilities, this $9 billion is the equivalent of about 40 percent of the industry's present investment in refining facilities.

Such is the opinion of Dr. Robert E. Wilson, chairman of the board of directors, Standard Oil Company (Indiana), who spoke last month before the National Council of Independent Petroleum Associations. Dr. Wilson and President A. W. Peake of the same company said that shortage in the Midwest was due to transportation difficulties and the extremely high demand for products.

Inability to expand the industry's transportation system during the war, what with the continued scarcity of steel, may cause the oil shortage to be extended for three or four years. Projected pipe lines cannot be completed before and the Standard officials said that even when these lines are opened, the demand may have outstripped planned facilities.

"Also, we don't know if crude supplies at the receiving end of the lines will be large enough," Peake added. "However, based on present trends, we will have to depend more and more upon imported crude. If the Middle East is able to take care of Europe, we will get more crude from South America."

"Our company," Dr. Wilson said, is not directly interested in foreign crude because we do not use any. However, more imports likely will come in and, I believe, without upsetting the industry. South American crude will come to the East Coast, leaving more Gulf Coast crude for the Midwest."

Dr. Wilson pointed to the high cost of new refinery construction, declaring that new synthol plants for production of gasoline from natural gas cost about twice that of other refineries. He thought that synthetic fuel from coal is "somewhat in the future."

"Forty percent of the industry's present investment in facilities is a tremendous amount and we must make it clear that even though we are making more money right now, I do not think there is anyone taking out more than he is putting back into the industry. High construction costs and high depreciation offset the economies effected by the new type refineries.

Dr. Wilson's comments also touched on the matter of refining capacity statistics, he declaring there is no accurate figure because it depends upon throughput or yields of different products.

He said that there were three sets of industry figures on refinery production until the recent National Petroleum Council survey. Some companies, he pointed out had been giving different figures on their refining capacities to those compiling the three sets of statistics because the requests for data were sent to different men in the same organization and the information was not coordinated.

CRUDE-OIL CAPACITY OF REFINERIES
By States and Districts
(Preliminary as issued recently by the U. S. Department of the Interior, Bureau of Mines)
(Barrels daily—As of January 1, 1947)

	Crude Capacity		Crude Capacity
East Coast		**Oklahoma, Kans, Etc.**	
Delaware	3,500	Kansas	190,100
Georgia	5,500	Missouri	27,000
Maryland	56,000	Nebraska	8,350
Massachusetts	40,860	Oklahoma	214,960
New Jersey	277,955	South Dakota	460
New York (E)	36,235		
Pennsylvania (E)	368,000	Total	440,870
Rhode Island	16,400	**Texas Inland**	284,675
South Carolina	6,900	**Texas Gulf**	1,287,600
		Louisiana Gulf	352,300
Total	811,350		
		Arkansas-La. Inland	
Appalachian I		Alabama	3,000
New York (W)	50,175	Arkansas	51,700
Pennsylvania (W)	60,110	Louisiana Inland	48,550
West Virginia	14,200	Mississippi	8,000
Total	124,485	Total	111,250
		New Mexico	12,850
Appalachian II		**Other Rocky Mountain**	
Ohio (E)	66,500	Colorado	15,115
		Idaho	4,600
Illinois, Indiana, Etc.		Montana	40,480
Illinois	311,900	Utah	23,200
Indiana	264,275	Wyoming	77,167
Kentucky	58,800		
Michigan	102,095	Total	160,562
Minnesota	8,000		
Ohio (W)	158,300	**California, Etc.**	
Tennessee	5,500	California	989,970
Wisconsin	5,000	Washington	10,200
Total	913,870	Total	1,000,170
		Total United States	5,566,482

CAPACITY OF SHUTDOWN REFINERIES*
(included above)

East Coast	.....	Louisiana Gulf	3,000
Appalachian I	2,000	Arkansas-La. Inland	31,500
Appalachian II	.....	New Mexico	.....
Illinois, Indiana, etc.	17,600	Other Rocky Mountain	3,595
Oklahoma, Kansas, etc.	5,360	California, etc.	32,400
Texas Inland	15,500		
Texas Gulf	44,500	Total United States	155,455

* Capacities of refineries that were completely shutdown on January 1, 1947. Idle portions of operating refineries are not included.

Former President of Western Petroleum Dies

C. L. Henderson, 56, president of Vickers Petroleum Company, Wichita, Kan., and president of the Western Petroleum Refiners Association 1940-46, died August 26 at Wichita. He had actively participated in various committee activities during the war and was prominent in the petroleum industry. He started in the oil business in 1917 with Sterling Oil and Refining Company, and became affiliated with Vickers in 1923. A member of PIWC during the war, he also served as a member of the National Petroleum Council.

Hartmann Dies

William V. Hartmann, 76, died August 24 in Pittsburgh. For many years and up until he retired a year ago, he had been a vice president and member of the board of directors of Gulf Oil Corporation.

Henry Grattan Flood Dies

Henry Grattan Flood, 52, assistant manager of the marketing-engineering department, Shell Oil Company, Inc., New York, in charge of construction and maintenance, died suddenly on July 31 in Albany, N. Y., while on a business trip. His home was at 210 E. 68th

GILBERT

MODEL DM-1 UNIVERSAL ELECTRO-HYDRAULIC

CHIME MACHINE

STRAIGHTENS CHIMES, STOPS CHIME LEAKS, AND WILL REMOVE HEAD OR BOTTOM FROM

STEEL SHIPPING DRUMS

This machine reconditions the chimes of used steel drums. At one operation it will straighten the chime even though the chime is very badly bent or distorted, bringing same into round as originally made and at the same time high hydraulic pressure compresses and rolls the chime preventing leakage in any properly made drum. When it is desired to shear the top, or bottom from drums this can be accomplished by substituting a shearing wheel, (which is furnished with the machine) for the pressure wheel. This substitution can be made quickly. The head or bottom can be cut from the drum cleanly and without leaving jagged edges. The chime is straightened and brought into round in this operation also. The entire time required for any operation is just a fraction of a minute for each end of drum.

Originators And Builders of

OUR BEST SALESMAN IS THE MACHINE WE BUILD

DRUM RECONDITIONING MACHINERY

Our Machines Are in Use Throughout the U. S. A. And in Many Foreign Countries.

L. M. GILBERT COMPANY

Philadelphia 6, Pa., U. S. A.

THE MONTH...

Street, New York City. He had been connected with Shell and associated companies since 1928, when he joined Asiatic Petroleum Company.

Old Named Consultant to Atomic Energy Commission

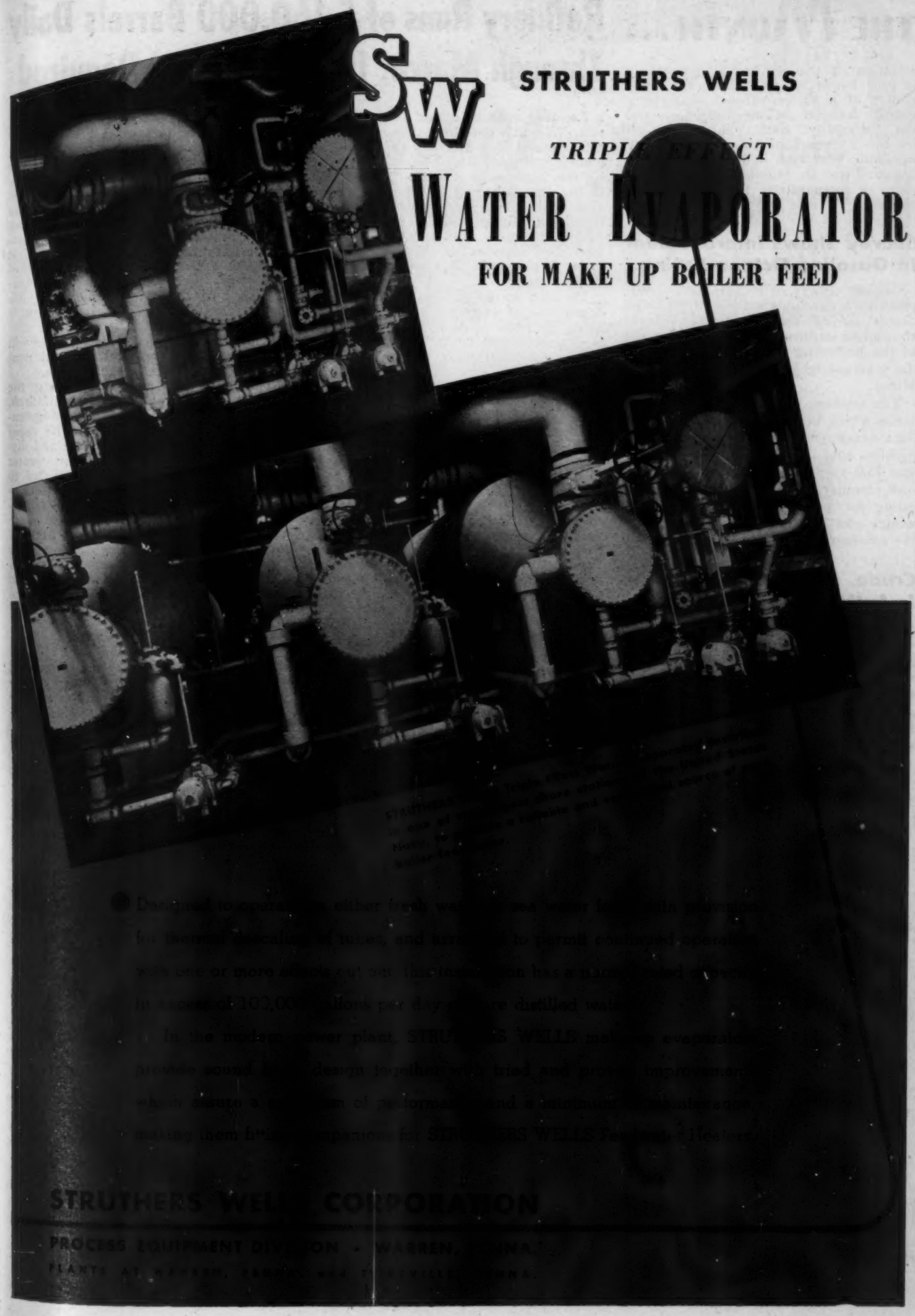
Dr. Bruce S. Old has been appointed consultant to the Atomic Energy Commission, division of research, in the capacity of chief metallurgist. Dr. Old will continue his present work with Arthur D. Little, Inc., Cambridge, Mass., industrial research laboratory, thus serving the Atomic Energy Commission on a part-time leave of absence. Dr. Old will assist in organizing the work of the commission in the metallurgical field.

DR. BRUCE S. OLD

During the war Dr. Old served as commander in the office of Research and Invention of the Navy, where he was engaged in planning and coordinating research on guided missiles, jet propulsion, and metallurgy. Dr. Old was graduated from the University of North Carolina in 1935 and received his doctorate from Massachusetts Institute of Technology in 1938.

Pan American Continues Six Chemical Fellowships

D. J. Smith, President, and Mr. L. W. Moore, General Manager of Research, of the Pan American Refining Corporation, have announced that the corporation has extended its six graduate fellowships in chemistry and chemical engineering for another year. No restrictions have been placed on the fellows' fields of investigation other than that they be within the scope of Chemistry and Chemical Engineering. The



SW STRUTHERS WELLS

TRIPLE EFFECT

WATER EVAPORATOR

FOR MAKE UP BOILER FEED

STRUTHERS WELLS CORPORATION

PROCESS EQUIPMENT DIVISION - WARREN, PENNA.

PLANTS AT WARREN, TITUSVILLE AND DENVER

THE MONTH...

selection of the fellow is left entirely in the hands of the University. The choice of a thesis subject shall be a mutual decision between the fellow and the University. Each fellowship shall be for a period of time equal to an academic year and, in general, shall be assigned to an individual in his last year of preparation for his doctor's degree.

Survey Shows Improvement In Gasoline Octane Rating

Octane ratings of regular and premium-priced gasolines sold in the United States during the winter of 1946-47 showed an improvement over the ratings of the preceding summer, according to the semi-annual survey of the Bureau of Mines.

The semi-annual survey, the 21st in a series which began in 1936, showed that the average octane rating of regular-price gasoline sold in this country last winter was 75.0, compared with 74.4 the previous summer, and the average octane rating for premium-price gasoline last winter was 78.5, compared with 78.3 for the summer of 1946.

Crude, Products Survey Is Authorized by Compact

A survey of all crude and products stocks, showing their character and availability, including location by states, was authorized at the August meeting of the Interstate Oil Compact Commission. A similar survey was made in 1937 by the Bureau of Mines, but such authentic data have not been available since.

Refinery Runs of 5,160,000 Barrels Daily Through March, 1947, Believed Required

Refinery runs of about 5,160,000 barrels daily at least through next March are required to meet the over-all petroleum products demand, it was declared by the Economics Advisory Committee of the Interstate Oil Compact Commission which made a report at the August meeting in Great Falls, Mont. Extraordinary measures will be needed to get additional supplies into the Midwest in order to prevent a shortage in that area next winter.

Portions of the greneral report of the committee, of which Dr. Richard J. Gonzales, Humble Oil & Refining Company, is chairman, follows:

Capacity operations by the industry for some time into the future will be required to supply the large and rapidly increasing demands for petroleum products. Extraordinary measures to move additional supplies into District 2 (the Midwest) will be needed to prevent shortages in that area next winter. Crude oil production and refinery crude runs of about 5,160,000 barrels daily will be required, at least through next March, to meet demand. Even higher operations would be helpful in building up stocks to levels that would facilitate distribution and provide some margin of safety against the possibility of an unusually cold winter or other unforeseen developments that may increase demands above the levels estimated by the committee.

The present supply problems are caused by an unusually large growth in demand and by lack of adequate transportation facilities from producing to consuming areas, since supplies are greater than ever before. Domestic and export demand this year will be about 5,800,000 barrels daily, or 9 percent greater than in 1946. These estimates take into account the latest U. S. military requirements and exports of 440,000 barrels daily, which equal anticipated imports. The increase in demand exceeds the production of the state of Louisiana, for example, which is the third largest oil producing state in the U. S. During the first quarter of 1948, when the peak winter requirements develop, the committee estimates that demand will be 6,165,000 barrels daily, on the basis of normal weather and a moderate recession in business activity. This preliminary estimate is subject to revision to take into account experience in the next few months, and the supply problem will be even more difficult if demand next winter exceeds present estimates.

The winter period, including the months from October through March, now constitutes the peak consuming season for petroleum products. The rapid growth in demand for kerosine and distillate fuel oils for heating in winter makes it necessary for the industry to take unusual measures to meet requirements for these products. It will apparently be necessary for refineries to achieve larger yields of distillate fuel oils than ever before, and for stocks to increase rapidly during the next few months, in order to make available the necessary supplies. Even then, transporting supplies to the right points will be a major problem.

Supply

The industry's capacity to produce and refine crude oil is adequate to meet the demands now anticipated for next winter. Committees of the National Petroleum Council have estimated that in the United States the maximum efficient capacity to produce crude oil is 5,271,000 barrels daily and that refining capacity is 5,648,000 barrels daily, including the capacity of some shutdown plants.

Immediately, therefore, the industry's problem does not arise from a shortage of supply or from inadequate refinery capacity, but from a lack of facilities to move oil from areas with additional available capacity, such as West Texas and the Rocky Mountains. If demand continues to increase at a rate of 5 to 10 percent annually, however, the industry will be faced with the major problem of developing adequate supplies by means of 1) additional drilling and imports, or 2) the manufacture of liquid fuels from natural gas, coal, and oil shale.

The most serious problem now existing is that of moving supplies in sufficient quantities into District 2. Pipe lines are being operated at capacity in the area, and substantial movements by tank cars at high cost are already being made. The present rate of deliveries still does not appear adequate. Extraordinary efforts to increase tank car and barge movements into the Midwest will be required promptly if demands are to be met fully next winter. Such efforts can be especially helpful during the remaining summer months, while the railroads can handle additional cars, for winter conditions will reduce the quantities that can be delivered by tank cars, barges, and pipe lines.

The industry has under way a number

Interstate Oil Compact Commission's U. S. Petroleum Situation Report
(THOUSANDS BARRELS DAILY)

	1946	1947 Actual 1st Quarter	1947 Estimate 2nd Quarter	1947 Forecast 3rd Quarter	1947 Forecast 4th Quarter	1947 Forecast Year	1948 1st Quarter Prelim.
Demand:							
Gasoline	2138	2005	2375	2450	2265	2274	2080
Kerosine	268	393	245	215	360	303	410
Distillate Fuel Oil	746	1130	705	630	1015	870	1250
Residual Fuel Oil	1333	1557	1375	1285	1480	1425	1550
Other	836	832	955	1025	920	933	875
Total Demand†	5321	5917	5655	5605	6040	5805	6165
Domestic Demand	4907	5496	5165	5155	5640	5365	5765
Exports	414	421	490	450	400	440	400
Supply:							
U. S. Oil Production*	4749	4796	5050	5160	5160	5042	5160
Natural Gasoline	321	352	350	355	365	356	370
Imports	370	482	430	425	410	437	440
Total Supply	5440	5630	5830	5940	5935	5835	5970
Stock Changes:							
4 Major Products	+99	—355	+77	+412	—79	+14	—244
Refinable Crude Oil	+16	+50	+66	—65	—15	+8	+60
Others	+4	+18	+32	—12	—11	+8	—11
All Oils	+119	—287	+175	+335	—105	+30	—195
Closing Stocks (Million Barrels):							
4 Major Products	222	190	197	235	227	227	205
Refinable Crude Oil	225	229	235	229	228	228	233
Others	60	62	65	64	63	63	62
All Oils	507	481	497	528	518	518	500
Crude Runs to Stills	4760	4800	4925	5200	5165	5023	5130

* Forecast shows amount required to meet demand and maintain stocks.
† If transportation or other causes prevent delivery of the needed petroleum products, the actual consumption may be reduced accordingly.

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of pipe line projects to move more oil into District 2, but little relief will be had from such construction until 1948. Such projects should be expedited to the maximum extent so that the transportation situation will be improved as soon as possible, and certainly before the winter of 1948-49.

Additional tanker transportation from the Gulf Coast to the East Coast will also be required next winter. It is understood that sufficient tankers can be made available for the anticipated movement, although this may require that some tankers now inactive be returned to service by next winter.

Stocks

Stocks of crude oil and the four major products in the United States were about 10,000,000 barrels higher at the end of July than a year ago, but the change has not been uniform by areas. In the Pacific Coast area, stocks were 10,700,000 barrels higher; in District 2 stocks were about 16,000,000 barrels lower; and in Districts 1, 3, and 4 stocks were about 15,000,000 barrels higher. These comparisons reflect the difficulty encountered in moving adequate supplies into District 2 and indicate the serious situation which exists in that area.

The committee's forecast indicates a small addition of 3,000,000 barrels to petroleum stocks during the nine months ending next March. Such a change can only be accomplished by large additions in the third quarter, since stocks will be reduced during the following six months by heavy winter demands. The stock level shown at the end of next winter is about 4 percent higher than on March 31, 1947, but that is about the minimum that could be considered adequate in view of the increasing demand and the tight situation existing in stocks of kerosine and distillate at the end of the first quarter of this year.

Conclusion

The following conclusions summarize the principal points of this report:

1) Crude oil production and refinery runs averaging 5,160,000 barrels daily or more, will apparently be required to meet demands through March, 1948.

2) Increased movements by tank cars and barges into District 2 are essential if demands for heating oils are to be met in that area.

3) Expansion of the industry's pipe line and refining facilities would ease the present situation by providing a desirable margin of safety.

4) The upward trends in demand requires a continuation of active exploration and development.

5) To prepare for winter demands, it is necessary for stocks to be built up substantially prior to the beginning of the heating season.

Committee members include Oliver S. Ambrose, Albert J. McIntosh, John W. Boatwright, Joseph H. Salmon, James V. Brown, J. Melville Sands, Austin Cadle, Henry J. Struth, J. A. Cogan, Sidney A. Swensrud (absent), E. Madison, Fred Van Covern, Clarel B. Mapes, and Dr. Gonzalez. Councillors are S. P. Coleman, E. DeGolyer, J. E. Pogue, and Alexander Sachs.

New Members of Refiner Staff

SILAS B. RAGSDALE

GORDON W. ALEXANDER

TWO of the most recent acquisitions to the expanding editorial staff of PETROLEUM REFINER are shown above.

At left is Silas B. Ragsdale, who became managing editor following the death last May of J. Kent Ridley, veteran Gulf Publishing Company editorial man. Ragsdale, before coming to Houston about four years ago, had been managing editor for a score of years of the two daily newspapers at Galveston. Up until his switch to the REFINER, he had been managing editor of *World Oil* (formerly *The Oil Weekly*). Ragsdale had previous service with Gulf Publishing Company, having been managing editor of *The Oil Weekly* in 1920, later transferring to the Tulsa office for several months before returning to the *News* at Galveston. He got his B.A. degree from the University of Texas in 1918. Ragsdale is married, has a son who is a senior at the University of Texas and a daughter a senior in Lamar High School, Houston.

Gordon W. Alexander, right, joined the REFINER staff as associate editor on August 1, 1947. Formerly a chemist in the Taylor Refining Company refinery at Corpus Christi, Texas, Alexander has a wide acquaintance and a wealth of experience which will be assets as he contacts the personnel of the industry during coming months. He will make personal calls at refining plants throughout the nation and will pass on to readers through the REFINER the results of these visits. Alexander attended St. Mary's University at San Antonio, and worked in the traffic department of Associated Press for two years before going to Corpus Christi. He had been with Taylor for nearly 11 years. Alexander is married and has an 8-year-old son.

Petrol Terminal Buys Refinery at Texas City

Petrol Terminal Corporation of Philadelphia was the successful bidder for the Texas City refinery built by the government and operated during the war by American Liberty Oil Company, WAA announced early this month. Petrol's bid was $3.25 million with the next high bid entered by Sid Richardson, Texas operator.

Gulf Fellowship

A fellowship in chemical engineering at the University of Oklahoma has been established by Gulf Oil Corporation and appointment will be made for the period commencing September 1, 1947. The stipends amounts to $1000 per academic year, applicants must have a bachelor's degree in chemical engineering and be candidates for the master's degree in that branch. Address Dr. R. L. Huntington, chairman School of Chemical Engineering, University of Oklahoma, Norman.

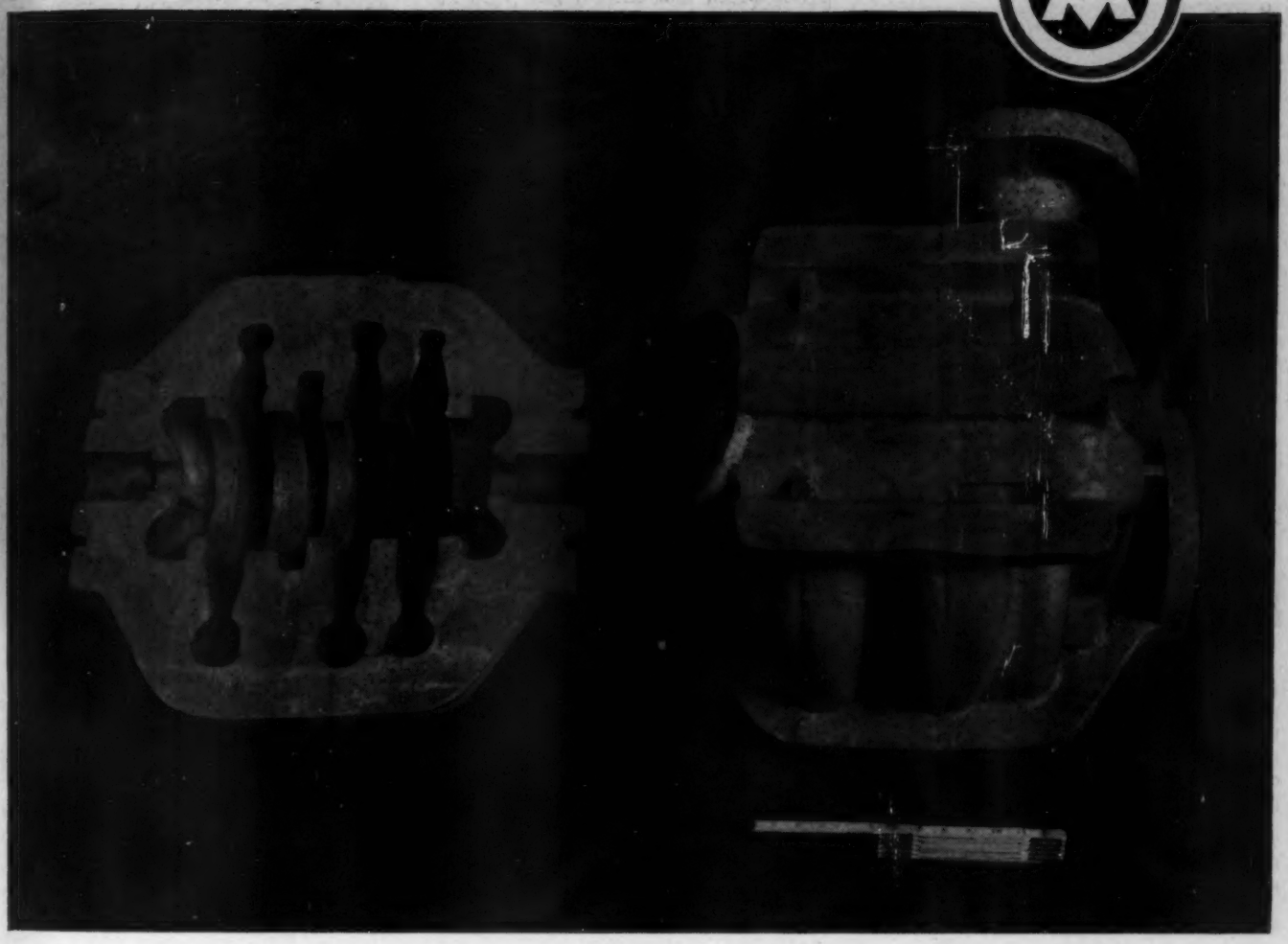
Fire at Whiting

A loss of 24,000 barrels daily capacity for processing crude oil was lost late in August when the Standard Oil Company (Indiana) Whiting, Ind., plant was damaged by fire. Three weeks previously fire also had damaged another 24,000 barrels daily capacity which will not be back in operation until October 1. Damage by the second fire cannot be repaired for "many weeks," it was said.

Spencer Named President Of Sinclair Refining

H. F. Sinclair, president of Sinclair Oil Corporation and Sinclair Oil Refining Company on September 3 announced he had resigned the presidency of the refining company and will be succeeded by P. C. Spencer.

This company, the most important subsidiary of Sinclair Oil Corporation,



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FORGINGS AND RINGS

THE MONTH . . .

P. C. SPENCER

includes the crude oil and products pipe line transportation, refining and marketing operations of the parent firm. Sinclair will continue as president of the parent company.

Spencer's presidency, it was said, is "only the first" of official changes being made for the purpose of placing younger men in the organization.

Spencer has been active in the oil and gas industry since 1922 and general counsel of the corporation since 1946.

Volwiler to Get Scroll

The Honor Scroll of the American Institute of Chemists will be presented to Dr. Ernest H. Volwiler, executive vice president, Abbott Laboratories, on October 10 in Chicago. The scroll is being awarded to Dr. Volwiler for his contributions to the field of medicinal chemistry, for his outstanding work in the organization of research programs, and for his active part in furthering the work of scientific societies.

Volume on Hydrocarbons Under Pressure Is Issued

Now available to engineers in the field of petroleum and natural gas, who are interested in data on the physical properties of the petroleum hydrocarbons, and who often find it necessary to enlarge the theories and add to the physical data provided by the early experiments, is a new book, "Bibliography for Physical Behavior of Hydrocarbons Under Pressure and Related Phenomena," by Dr. Donald L. Katz, Professor of Chemical Engineering, and Michael J. Rzasa, graduate student, University of Michigan, Ann Arbor. The bibliography conveys some of the early history of our scientific knowedge of oil and gas mixtures beginning in 1860. A few articles prior to 1860 have been included for their historical interest. These data on early experiments on the behavior of hydrocarbons form the background for present day engineering calculations.

For the period from 1860 to 1910, a series of journals were selected for an almost page-by-page survey to discover data on the physical properties of the petroleum hydrocarbons and associated pressure phenomena. A short abstract has been prepared of these articles to indicate the type and extent of the data. Title of articles only are given after 1910. Some of the journals covered to 1910 were carried to the present time while others were not abstracted after that date. Several journals were surveyed that started after 1910 and contained articles on physical properties, critical phenomena, and phase behavior of current interest.

The bibliography is prepared in two parts. Part I contains a list of 1951 references and abstracts, and in Part II the references in Part I are assembled by subjects to facilitate a literature search in any given field.

Publisher of the book is J. W. Edwards, Inc., Ann Arbor.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1946:									
January 26	4,626	4,553	220,544	13,622	101,737	5,720	29,498	8,411	39,722
March 2	4,726	4,779	229,430	13,871	104,462	5,888	25,148	8,634	38,441
March 30	4,425	4,684	224,994	13,896	104,715	5,337	28,240	8,738	37,746
April 27	4,672	4,685	224,443	14,228	99,631	5,568	30,466	9,204	39,404
May 25	4,759	4,857	222,214	14,322	95,769	5,463	32,973	8,908	43,368
June 29	4,957	4,854	223,883	14,500	92,333	5,325	37,762	8,828	46,447
July 27	4,926	4,896	223,756	14,535	88,626	5,817	44,316	8,217	49,517
August 31	4,833	4,901	225,672	15,405	86,813	5,374	53,858	8,357	53,037
September 28	4,778	4,829	221,903	14,538	85,854	5,450	57,903	8,158	56,914
October 26	4,730	4,758	221,184	14,863	84,623	5,710	65,499	7,728	60,872
November 30	4,795	4,707	225,119	15,145	88,371	5,228	66,062	7,672	58,647
December 28	4,713	4,968	226,111	15,604	93,126	5,931	58,941	8,181	53,427
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,357	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	8,532	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,860	5,435	32,286	8,186	42,668
May 31	5,024	5,000	239,370	14,709	95,876	5,732	36,032	8,910	45,224
June 28	5,109	5,093	236,221	16,070	91,806	5,606	41,721	8,298	48,490
July 26	5,084	5,162	231,357	16,142	85,812	5,708	47,097	8,738	52,497
August 30	5,157	5,209	228,281	16,753	84,105	5,919	54,808	8,962	55,242

MATTHEW VAN WINKLE

MATTHEW VAN WINKLE, who recently was appointed associate professor of chemical engineering at the University of Texas, comes to Austin from the University of Michigan where he had been assistant professor of chemical engineering. During the war he directed a U. S. Army ordnance project in the Engineering Experiment Station.

VanWinkle was graduated from Purdue University in 1933 and joined the technical staff of Cities Service Oil Company at Okmulgee, Okla., where he remained until 1939. The following years he acted as a consultant to various petroleum companies and was with Standard Oil Company (Indiana) until 1941 when he became assistant professor of chemical engineering at Pennsylvania State College as supervisor of extension work in petroleum and natural gas. In 1943 he joined the chemical engineering faculty at the University of Michigan where he was awarded the degree of Master of Science in 1945.

He is the author of the book "Aviation Gasoline Manufacture."

Technological Index Is Announced by OTS

The third volume of comprehensive index to reports on wartime technological developments in the U. S., in Germany and other foreign countries, including a number relating to oil, has been issued by the Office of Technical Services, Department of Commerce. The Index is for use with the OTS weekly Bibliography of Scientific and Industrial Reports on file at many public libraries.

"Lessons in Arc Welding" Now in Its Third Edition

The third edition of "Lessons in Arc Welding," published by The Lincoln Electric Company, Cleveland, Ohio, has been completely revised and is designed to assist new and experienced welders as well as persons interested in the subject, with instructions in all phases of arc welding. It includes 58 lessons

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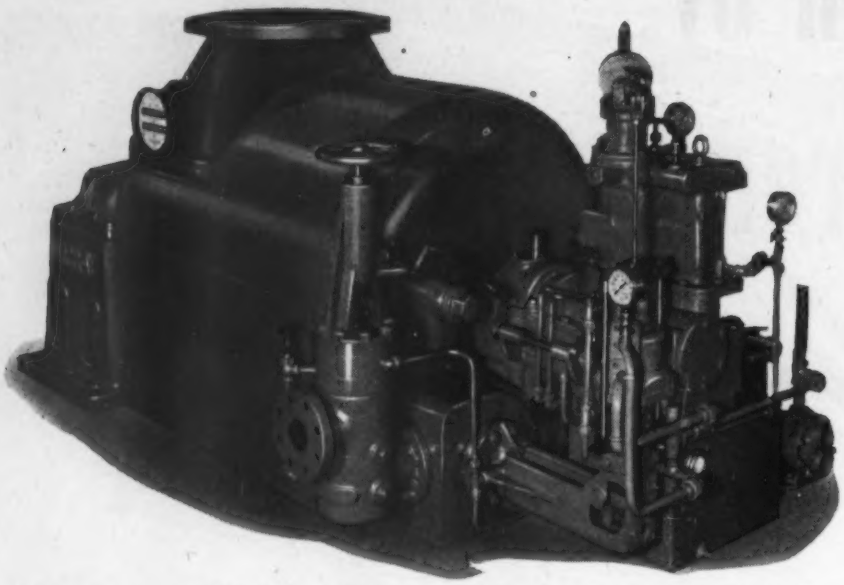

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THE MONTH...

and has 228 photographs, illustrations and drawings to supplement the text.

Published with the objective of aiding those interested in welding to use the process successfully and economically, the book explains the fundamentals of this method of joining metals by the fusion principle and incorporates such new informations as treatment of welding with alternating current, including machines and electrodes. New procedures covering large electrodes with recommendations on their uses, new type electrodes and their use, a number of lessons on pipe welding, and data on the qualification of welding operators are included. A feature of interest is a discussion of distortion with recommendations regarding its prevention and control, and a description of the principles of hard-facing.

Revised Pipe Fittings Recommendations Prepared

The proposed revision of "Simplified Practice Recommendation R185-42, Pipe Fittings," has been approved for promulgation, according to an announcement by the Division of Simplified Practice of the National Bureau of Standards. The revised recommendation will be identified as R185-47, Pipe Fittings, and will be effective from September 1, 1947.

The original recommendation became effective January 1, 1942, and subsequently served as the basis for WPB's mandatory orders. Following revocation of the last of these orders, the industry, in cooperation with the Division of Simplified Practice, drafted a revision, the purpose of which is to retain on a voluntary basis a standard of practice for these products.

The revision applies to gray cast iron, malleable iron and brass or bronze fittings. Fittings to which the recommendation does not apply are listed. As finally adjusted, the proposed revision includes a comprehensive group of fittings required for sprinkler systems, in addition to the regular lines for other purposes. The section dealing with brass or bronze fittings has been adjusted to provide for sectional, as well as general, needs.

Although it has been found necessary to increase the number of fittings which formerly comprised the simplified list, the items retained will still represent a substantial reduction from the number formerly listed.

Printed copies of the revised recommendation will be available on or about September 1. Pending printing, mimeographed copies may be obtained from the Division of Simplified Practice, National Bureau of Standards, Washington 25, D. C.

Hydrocarbon Research Results to Go Into Book

American Petroleum Institute Research Project 44, which was set up to determine the physical and thermodynamic properties of all hydrocarbons, is now publishing in book form the results of five years' research. This publication will be unique in that it will contain the collected data of industrial,

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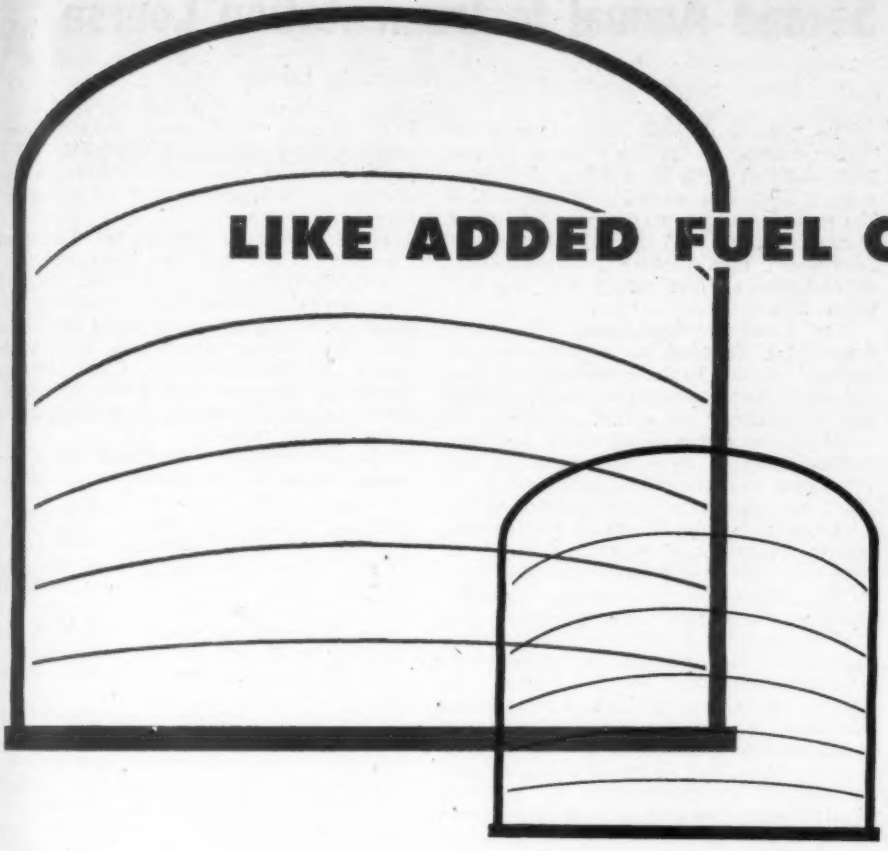

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THE MONTH...

DR. FREDERICK D. ROSSINI

academic, and government laboratories.

The information, resulting from these studies, will make possible more accurate and, therefore, less costly design of refinery equipment. This information on the physical properties of hydrocarbons will form a reliable basis for determining optimum temperatures and conditions for production of desired hydrocarbons in commercial processes and will make possible the more accurate design of equipment for the large scale production of hydrocarbons, which are now only test tube curiosities.

The fundamental purpose of the program is to identify the hydrocarbons and to establish an accurate, complete, and consistent set of values for each of them.

Direction of the work was under Dr. Frederick D. Rossini, chief of the Section of Thermochemistry and Hydrocarbons at the National Bureau of Standards, with Kenneth S. Pitzer, University of California, as associate director.

The bound volume will contain about 500 pages and will be issued as National Bureau of Standards Circular 461 entitled "Selected Values of Properties of Hydrocarbons."

Merriam to Teach

Dr. E. S. Merriam of Marietta, Ohio, consultant for the natural gas industry, has joined the faculty of the Marietta College School of Petroleum on a part-time basis. He will teach courses in engineering materials, and gas production, distribution and utilization.

Dr. Merriam is a pioneer engineer in the field of gas by-products, holding 15 patents. He was among the first men to devise and publish methods for determining the amount of gasoline in natural gas.

Large Attendance at Texas A.&M. Second Annual Instrumentation Course

C. C. PRYOR, Associate Editor

The Second Annual Short Course on "Instrumentation for the Process Industries" held at A. & M. College of Texas, August 27-9, was attended by more than 250 technicians from refineries, chemical plants, gasoline and cycling plants, and instrument manufacturing companies. Attendance at last year's meeting totaled 220.

The sessions throughout the three days were devoted to presentation of papers on the basic considerations involved in instrumentation system design and discussions of actual examples of plant systems employing these systems. Several papers were presented on the economic and organizational features of plant instrumentation and instrument departments. Some of the newer instruments and their uses in various fields also were discussed. One of the features of the course was the exhibits of instrument and equipment manufacturers.

Presentation of the first paper, "Economics of Instrumentation in the Process Industries" was made by Dr. C. M. Blair, Carbide and Carbon Chemicals Corporation of Texas City, following an address of welcome by Dean H. W. Barlow of the school of engineering. "Functions and Responsibilities of a Plant Instrument Department" (full text on page 98 of this issue) was presented by J. G. Kerley, Shell Oil Company, Inc., New York.

F. H. Trapnell, E. I. du Pont de Nemours and Company, Wilmington, Delaware, discussed "Flexibility in Unified Process Control Systems." He emphasized the importance of functional flexibility—providing the means of making allowances for contingencies which necessitate or make desirable the changing of either measurement control points, or both, after start of operation—in obtaining maximum flexibility, economy, and safety of operation. "Instrumentation as Applied to Speed Control" was given by J. G. Wilson, Shell Development Company, San Francisco, California. This paper covered the instrumentation for control of equipment such as compressors and pumps.

H. U. Fisher, Monsanto Chemical Company Dayton, Ohio, discussed "Instrument Work in an Atomic Energy Laboratory." Among the interesting features of the new instruments described were the sizes, tolerances, and accuracies. "Instrumenting a Continuous Chemical Process" was given by H. C. Frost, Corn Products Refining Company, Argo, Illinois.

Porter Hart, Dow Chemical Company, Freeport, described some of the instrumentations system in use at the Freeport plant in his paper, "Sea Water Bromine Process Chemical Control Systems." Hart discussed pH and oxidation potential control, acid mixing, salinity recording, sulphur burner controls, bromine steaming out tower controls, gas analysis, and temperature controls.

R. H. Koehler, Pan American Refining Corporation, Texas City, presented a paper on "Instrumentation of a Hydroforming Unit." The paper described automatic timed sequence operation of electric motor operated valves, interlocking controls, push-button operation of equipment, and master and dormant timers, used in the hydroforming unit in the Texas City plant. Koehler attributed much of the successful operation of the unit to the reliability of the electrical and mechanical equipment.

"Instrumentation of Cycling Plants" by A. J. L. Hutchinson, Fish Engineering Corporation, Houston, was presented by Tom Tabbert. (See page 15.) Nelson Gildersleeve, General Electric Company, Schenectady, New York, described a number of new instruments in "Instrumenting Physical Methods of Chemical Analysis." Gildersleeve pointed out that instrumentation in the field of chemical analysis equipment opened new horizons for research by instrument manufacturers and technicians. Broader usage of such instruments as the mass spectrometer and others will bring these instruments directly into the field of the instrument technician or engineer in the not too distant future.

The afternoon of the last day of the sessions was devoted to a question and answer period with a panel consisting of the speakers on the program. Questions were submitted in writing, through use of a collection box during the sessions, and presented to the panel by W. H. Fortney, presiding chairman.

The course was conducted by the Department of Chemical Engineering under the chairmanship of Dr. P. G. Murdoch, Professor of Chemical Engineering. Presiding chairman of the sessions were J. A. Parker, Shell Oil Company, Inc., Houston; C. F. Tears, Process Engineers, Inc., Dallas.; M. K. Anderson, Carbide and Carbon Chemicals Corporation, Texas City; R. E. Hansen, Leeds and Northrup Company, Houston; R. L. Mallory, Brown Instrument Company, Houston, and W. H. Fortney, Humble Oil and Refining Company, Baytown.

Compressed Air Handbook Is Published by Institute

First edition of "Compressed Air Handbook," (400 pages, $3) has been issued by Compressed Air and Gas Institute, New York, and is a reference text on applications, installation, operation and maintenance of compressing equipment and air-powered tools. In addition to data not heretofore published in a single volume, the handbook contains the standard reference material formerly published as "Trade Standards." Included are definitions, test standards and numerous basic tables and formulae.

Object in editing was to provide a comprehensive volume of reference data which would meet technical needs and serve the layman with information on the utility of compressed air power.

The book represents the collective knowledge and experience of 19 member companies of the Compressed Air and Gas Institute, and was compiled over a two-year period as a joint activity of the Institute's educational and technical committees.

SCIENCE AND TECHNOLOGY ABSTRACTS

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Traver Road, Ann Arbor, Michigan
under supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Preparation and Physical Properties of Several Aliphatic Hydrocarbons and Intermediates. F. L. HOWARD, T. W. MEARS, A. FOOKSON, P. POMERANTZ AND D. B. BROOKS, *J. Research, Nat'l. Bur. Standards* **38** (1947) 365-95.

Because preliminary investigations indicated that some of the higher paraffins might be superior to isooctane in knock ratings, a project was started in July, 1937, for the purpose of preparing the paraffin hydrocarbons that might be of interest in combat aviation fuel. This project has been actively followed since that time. The authors describe the methods of preparation and purification of three pentanes, four hexanes, three heptanes, four octanes, eight nonanes, seven decanes, four hexenes, five octenes, six nonanes, six decenes, and several alcohols, ketones, esters and alkyl halides. Physical properties are tabulated including freezing point, boiling point, the variation of boiling point with pressure, refractive index and density, and the variations of these properties with temperature.

The Polymerization of Olefinic Substances by Friedel-Crafts Catalysts. J. P. W. HOUTMAN, *Jour. Soc. Chem. Ind.*, 66 (1947) pp. 102-3.

It has been found in several reactions that Friedel-Crafts catalysts are effective only when traces of water are present. The author found that this does not apply to the polymerization reaction of iso-butene with BF_3 and $AlCl_3$ under conditions in which high-molecular weight products are formed. On the other hand, some indications were found that the reaction proceeds more slowly when working under dry conditions. The phenomena observed are explained in the most satisfactory way by accepting a polarizing effect of the positive metal atom on the olefin. Some possible explanations are given for the phenomena found by Polanyi and coworkers that indicate that presence of moisture can be important in certain cases. A bibliography of 6 references is included.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

Hexamethylene chloride
Octamethylene chloride
Nonamethylene chloride
Decamethylene chloride
Dodecamethylene chloride
Triethyl aluminum
Trimethyl aluminum
Thioindoxyl-2-carboxylic acid
Dialkyl or diaryl peroxides
Alkene sulfonic acids of 16-18 carbons
Alkene keto sulfonic acids of 16-18 carbons
2-Methyl-3-methoxy-1,4-naphthaquinone
Dehydromucic acid
3-Phenylcyclopentene
Benzochrysene
Benzoperylene
Benzofluorene
Vinyl dimethylamine
3-Phenylcyclohexene
2-Isoimidazole
2,1,3-Triazole
Furazan.

Chemical Compositions and Reactions

The Application of a New Notation to Petroleum Hydrocarbons. C. MALCOLM DYSON, *Jour. Inst. of Petroleum* **33** (1947) pp. 356-62.

The need for a new method of designating organic compounds has been felt for some time. In a recent monograph written by the author the reasons for adopting a cipher system as the basis for a new notation are given in detail. In the present communication the particular impact of the new system on the nomenclature of petroleum hydrocarbons is given. The notation describes the structure in linear form and is referred to as a "cipher." The cipher is divided into sections by stops: each section is referred to as an operation. Where a letter is followed by a figures as in "C7" the figures is termed a *modulant;* where the figures precedes the letter it is termed a *locant,* for its function is to give the position of what follows it. To make the cipher for a saturated acyclic hydrocarbon, the longest chain is first located. This is always, without exception, the starting point of the cipher. Thus, in the case of a straight chain hydrocarbon of 3, 7, or 16 atoms the cipher would be C3, C7, or C16. For branch hydrocarbons, the cipher states the branches in order of decreasing magnitude. The author proceeds to apply the method to straight chain and to aromatic and other polycyclic hydrocarbons. A further advantage of the notation is that it is easily applicable to punch-card manipulation. This means that the complete details of the structures can be expressed in the form of holes in cards that can later be manipulated by sorting and automatic printing machinery.

Petroleum as a Base Material for Chemical Industry. J. C. G. BOOT, *Trans. Institution of Chem. Engrs.* **21** (1943) pp. 41-7.

Petroleum and natural gas are discussed as sources of raw materials for the chemical industry. The products derived through dehydrogenation, oxidation by steam, oxidation by air, halogenation, and nitration are briefly considered. The place of the olefins, such as ethylene, propylene, normal butylenes, isobutylene, amylenes and higher olefins as chemical raw materials, is reviewed.

High Molecular Weight Hydrocarbons. II. Five New Hydrocarbons Derived from Sebacic Acid. MILTON D. SOFFER, NATALIE S. STRAUSS, MARJORIE D. TRAIL AND KENNETH W. SHERK, *Jour. Am. Chem. Soc.,* **69** (1947) pp. 1684-8.

Five new high molecular weight hydrocarbons, 1,14-diphenyltetradecane, 1-phenyl-12-n-propylpentadecane, 4-phenyl-13-n-propylhexadecane, and the cyclohexyl analogs of the latter two were prepared in a high state of purity. Dimethyl sebacate was the starting material for all the syntheses. Details of the preparations are given.

Selective Demethylation of Paraffin Hydrocarbons. VLADIMIR HAENSEL AND V. N. IPATIEFF, *Ind. & Eng. Chem.* **39** (1947) pp. 853-7.

Branched-chain paraffin hydrocarbons react with hydrogen in the presence of a nickel or cobalt catalyst to form paraffins containing one less carbon atom and methane. The reaction involves the removal of specific methyl groups since those attached to secondary carbon atoms are removed much more readily than those bound to tertiary carbon atoms, while methyl groups attached to the quaternary carbon atoms are the most stable. The reaction occurs within narrow ranges of experimental condi-

tions. Data are given on the conversion of mixtures of 2,2,3-trimethylpentane and 2,3,4-trimethylpentane to triptane, 2,3-dimethylpentane, and 2,3-dimethylbutane. Results are also given on the demethylation of neohexane to neopentane. The effect of operating variables such as pressure, temperature, and space velocity is discussed. A diagram is given showing the apparatus used in the work and the procedure is described in relationship to this apparatus. Data are presented in considerable detail in tabular and graphical form and a bibliography of three references is included.

The Aluminum Chloride-Catalyzed Addition of t-Butyl Chloride to Propylene. VERLE A. MILLER, *Jour. Am. Chem. Soc.* **69** (1947) pp. 1764-68.

The paper presents a study of the structures of C_7 molecules obtained from the addition of t-butyl chloride to propylene in the presence of aluminum chloride. The condensation of t-butyl chloride with propylene at —30° in the presence of 2 g. of aluminum chloride per mole alkyl halide produces a 70 percent yield of heptyl chlorides. Under these conditions about 45 percent of the heptyl chloride fraction is composed of the primary addition product, 2-chloro-6,4-dimethylpentane, and the remainder is the rearranged product, 3-chloro-2,3-dimethylpentane, which is mixed with a small amount of 2-chloro-2,3-dimethylpentane. The principal fraction of the higher boiling mixture obtained is composed chiefly of decyl chlorides which were not further identified. At higher reaction temperatures and with more catalyst present, the reaction is more complex. The data are presented in considerable detail in tabular form.

Electronic Interpretation of the Reaction of Olefins with Organic Per-acids. DANIEL SWERN, *Jour. Am. Chem. Soc.* **69** (1947) pp. 1692-98.

The author discusses the reaction of olefins with organic per-acids and tabulates the reaction rates for the reaction of aliphatic and alicyclic olefins with peracetic acid in acetic acid solution. The reaction rates of olefins containing aromatic groups with peracetic acid in acetic acid solution and with perbenzoic acid in chloroform or carbon tetrachloride solution are given in tabular form. An electronic interpretation of the reaction of olefins with organic per-acids is proposed. This is based on the assumption that the peroxide oxygen is per-acids is electrophilic, and is readily released in the presence of a nucleophilic group, such as the double bond. When electron-releasing groups are attached to, or are in close proximity to, the double bond, the reaction rate is increased because of the increased electron density of the ethylenic system, which results in an increase in the nucleophilic properties of the double bond; when electron-attracting groups are present, the reaction rate is decreased because of a decrease in the nucleophilic properties of the double bond.

The Aerial Oxidation of Scottish Shale Wax. A. E. J. PETTET AND W. S. GREAVES, *Jour. Soc. Chem. Ind.* **66** (1947) pp. 126-30.

It was found in the oxidation of Scottish shale wax with air that a satisfactory rate of oxidation was attained by oxidizing a mixture of 60 percent fresh wax with 40 percent of material from previous runs, at a temperature of 110° C. Air for oxidation at the rate of 4 cu. ft./hour/100 g. of the mixture, was best introduced in a finely divided state by means of a ceramic filter block, and either cobalt or manganese oleate at 1 percent concentration proved to be a satisfactory catalyst, with a slight advantage in favor of cobalt oleate. An aluminum apparatus was preferable to one made of glass, since the considerable induction period evident in glass was eliminated when aluminum was used. Adequate space was necessary in the reaction chamber because the mixture frothed. With the manganese catalyst in presence of unsaponified material, the yield of C_{10}-C_{20} acids arose from 7 percent when the reaction was taken to an acid number of 36 to 27 percent at acid number 186. The acetyl number of the final acids also tended to rise when the oxidation was carried to a high acid number but the exact point was not determined at which oxidation should be stopped to give optimum results, having regard both to quantity and quality of the acids formed. The wax could be almost completely oxidized, but no advantage was gained by doing this.

Effects of Impurities on Copolymerization of Isoprene and Styrene. ROBERT L. FRANK, CLARK E. ADAMS, JAMES R. BLEGEN, RUDOLPH DEANIN AND PAUL V. SMITH, *Ind. & Eng. Chem.* **39** (1947) pp. 887-93.

The authors find that the presence of traces of impurities in commercial isoprene obtained from petroleum has an important influence on the qualities of the isoprene for polymerization purposes. Of these impurities the paraffins, cycloparaffins, and simple acetylenes have little or no effect. Mono-olefins, for the most part, have a slight retarding influence on polymerization rate in emulsion polymerization. Certain olefins, however, having the structural unit $C{=}CCH$, have a substantially larger retarding effect than the others. This includes such compounds as 3-methyl-1-butene, isoprene dimer, and 1,3-pentadiene dimer. Other impurities that cause substantial retardation are 1,3-pentadiene, vinyl-acetylene, and carbon disulfide. Extreme retardation is caused by 1,-4-pentadiene, cyclopentadiene and lower mercaptans. In general, the greater the retardation the lower the intrinsic viscosity of the polymers obtained. Of the impurities tested only vinylacetylene appeared to cause cross linking. The method of action of these retarders is breifly discussed.

Effects of Impurities on Copolymerization of Butadiene and Styrene. ROBERT L. FRANK, JAMES R. BLEGEN, G. ESLER INSKEEP AND PAUL V. SMITH, *Ind. & Eng. Chem.* **39** (1947) pp. 893-5.

Nineteen possible impurities in butadiene and styrene were added in varying amounts to mixtures of butadiene and the effects on polymerization rates were determined. In amounts of 1 percent or less of the monomers used, the following appear to have no effect in emulsion polymerization: ethylbenzene, orthoxylene, phenylacetylene, methylphenylcarbinol, acetophenone, acetaldehyde, propylene, allene, isoprene, and ethylacetylene. The butenes and straight-chain pentenes show some retardation at a concentration of 1 percent. At higher percentages these compounds cause a marked decrease in conversion. Polymer conversions are lowered sharply by 1,-4-pentadiene and less markedly by 1-vinyl- 3-cyclohexene. Divinylbenzene and vinylacetylene (1 percent) have little or no effect on polymerization rates, but they do cause cross linking in the polymers. A bibliography of 5 references is included.

Polymerization. VII. The Structure of the Alfin Catalyst. AVERY A. MORTON AND MURIEL E. T. HOLDEN, *Jour. Am. Chem. Soc.* **69** (1947) pp. 1675-81.

The metallization of propylene by amol-sodium gives allylsodium as the sole product of monometallization. The allyl anion can be assumed to undergo an allylic shift. The metallization of 1-butene or 2-butene gives at least two monosodium products. These are the same irrespective of the butene used or of the presence of isopropoxide or of triethylamine. The result indicates that the butenyl anion undergoes an allylic shift. The metallization of 1-pentene gives only two mono products in the absence of isopropoxide or in the presence of n-propoxide or triethylamine. One of these products represents metallization at C_3 and the other at C_1. 2-Pentoxide is less effective than the isopropoxide in causing an alylic shift to occur in the pentenyl anion. The dicarboxylic acids isolated from the metallization of propylene and 1-butene indicate that the two metal atoms were located at the extreme ends of the alkyl chain. The results of the work are explained by the assumption of the doubly coordinated cyclic ring formula for the Alfin catalyst.

Vapor-Phase Nitration of Saturated Hydrocarbons. H. B. HAAS AND H. SHECHTER, *Ind. & Eng. Chem.* **39** (1947) pp. 817-21.

As a result of work done during the past 16 years it is now possible to generalize the complex reaction of vapor-phase nitration of saturated hydrocarbons. These generalizations are presented in the form of 13 rules. If cracking temperatures are avoided during the nitration no carbon skeleton rearrangement occurs. Simple paraffins or cyclo-paraffins yield products containing not more than one nitro group per molecule. Any primary, secondary, or tertiary hydrogen atom in a hydrocarbon is capable of substitution by a nitro group. This group can replace any alkyl group in a paraffin, but simple nitro products are not formed by fission of an unsubstituted cycloalkane. Highly branched hydrocarbons undergo less change during nitration than less branched or normal ones. Nitrogen dioxide and nitric acid yield identical products, but the latter gives better yields and higher nitration rates. Oxidation accompanies nitration. However, little nitric acid is reduced to nitrogen under optimum reaction conditions. Nitration of methane has an activation energy of approximately 52 kg.cal. per mole; thus nitration rates are greatly accelerated by increased temperatures. The reactions that result in the substitution of alkyl and cycloalkyl groups have a higher temperature coefficient than those that substitute hydrogen atoms. The temperature coefficients for hydrogen substitution are in the order: primary, secondary, tertiary. Total yields of nitro compounds vary little over a wide temperature range if exposure times and temperatures are correctly matched. There is, however, an optimum temperature for each hydro-

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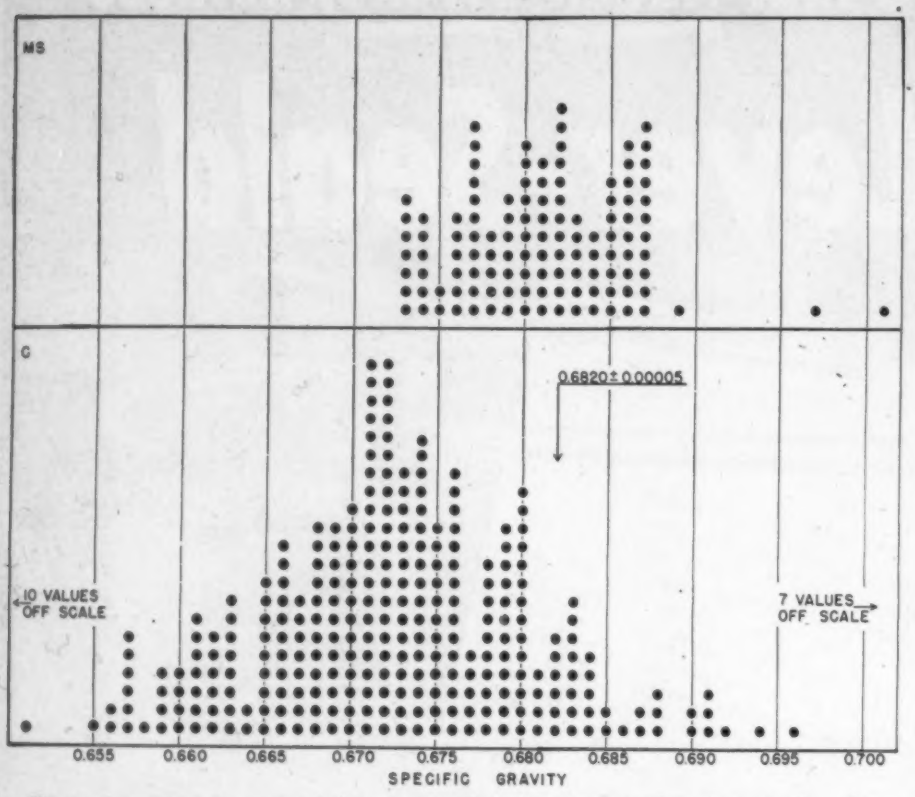

The mass spectrometer, one of the newer analytical instruments, has shown itself to be a remarkably useful apparatus in the analysis of gases and complex mixtures of gases. Many industries, such as gas, petroleum, chemicals, and rubber, rely heavily on gas analysis, and any improvement in methods or apparatus is of far-reaching importance. Although established chemical methods have long yielded valuable information concerning compositions of gases, they have serious limitations. The mass spectrometer offers an entirely new and different instrument for this type of analysis. It can in one operation resolve a very complex mixture of gases in a few moments of instrument time, although subsequent computing may require hours or even days, depending upon the complexity of the mixture and the method of computation employed, the National Bureau of Standards reports.

Frequency-distribution plots of data from cooperative analyses of a standard sample of natural gas by the mass spectrometer and established chemical methods reveal at a glance the actual state of gas analysis in this country at the present time. This typical plot, above, illustrates the range of value of specific gravity—only one of several items in a complete analysis—obtained by two of the most important methods of gas analysis. Twenty laboratories possessing a total of 21 spectrometers participated in the spectrometric tests, and 30 laboratories in the chemical tests. The values in the upper section marked MS were calculated from analyses by the mass spectrometer and those in the lower section C, from the chemical analyses. Every circle represents the specific gravity calculated from one analysis of the standard sample. The abscissas are numerical results derived from the analyses and the ordinates indicate the frequency with which they occur. For example, reading the upper (MS) section, it is seen that 7 analyses yielded the value 0.673, 6 gave 0.674, and so on. The known measured value was 0.6820 ± 0.00005. The entire study indicates a definite need for standardized apparatus and procedures in this branch of analytical chemistry.

carbon at a given pressure. Elevated pressures increase the reaction rate and the difficulty of temperature control without greatly affecting yields. The catalysts preferentially accelerate the competing oxidation reactions.

Effect of Pressure on Nitration of Methane. H. B. Hass, H. Shechter, L. G. Alexander and D. B. Hatcher, *Ind. & Eng. Chem.* **39** (1947) pp. 919-24.

The nitration of methane was studied at pressures ranging from atmospheric to 1000 pounds per square inch. Equipment that does not catalyze the oxidation of the reactants, but which is capable of maintaining excellent temperature control and heat transfer, is required to operate the process efficiently. A molal ratio of methane to nitric acid of at least 10:1 is needed to absorb the heat from the exothermic reaction. In general, the nitration reaction is more difficult to control as the operating pressure is increased, and oxidation catalysts deposited in the reaction tubes greatly decrease the conversion. Increase in operating pressure up to 100 pounds per square inch favors the conversion of nitric acid to nitromethane. A maximum conversion of 27.1 percent, based on the nitric acid consumed, was obtained at 444° C., a mole ratio of nitric acid of 10.5:1, and a gage pressure of 100 pounds per square inch in a reactor constructed from Pyrex tubing of 5-mm. outside diameter. It was concluded that no great advantage is to be obtained by nitrating methane at extreme pressures. The apparatus used in the work is described in some detail, and the data are presented at length in tabular and graphical form. A bibliography of 8 references is included.

Manufacture: Processes and Plant

The Effect of Vapour Composition on the Assessment of Fractionating Columns in Terms of Heights of a Transfer Unit. Part I. J. Anderson Storrow, *Jour. Soc. Chem. Ind.* **66** (1947) pp. 41-8.

By using a new "sampling" technique involving thermocouples to measure the condensation temperature of vapor mixtures in a wetted-wall fractionating column, it was possible to derive curves of vapor concentration along the contact path of the two phases. From these "concentration curves" estimations have been made of the effect on H.T.U. of vapor composition for various column lengths and operating conditions. Discrepancies between data obtained from the same type of column by other workers are found to be due largely to the effect of vapor composition. The present analysis indicates clearly the limitations of H.T.U. assessments based on the resistance to diffusion of the vapor film alone. A bibliography of 22 references is included.

Gas Absorption and Humidification in Cyclone Spray Towers. H. F. Johnstone and H. E. Silcox, *Ind. & Eng. Chem.* **39** (1947) pp. 808-17.

Measurements were made in a model cyclone tower on the rates of absorption of sulfur dioxide by alkaline solutions and on humidification of the gas. A cyclone spray tower consists of a vertical cylindrical chamber with a tangential gas inlet near the bottom and a central gas exit at the top. A spray of small droplets of the scrubbing fluid is introduced through nozzles on a manifold. The rotation of the gas in the chamber caused by the tangential entrance results in centrifugal forces that cause the spray droplets to travel outward at high velocities through the gas to the walls of the chamber. Such towers have found numerous applications in the removal of mist and dust particles from large quantities of gases. The effect of entrance design, gas and liquor velocities, and nozzle spacing are correlated in such a manner that the performance of large towers can be predicted. The towers provide high rates of absorption as well as good efficiency for the removal of finely divided dust particles. They may be operated over a wide range of conditions and loading ratios of liquid to gas. Their simplicity and low pressure loss should make them useful in industry for treating large quantities of gases.

Ethylene Purification by Absorption Process. Ludwig Kniel and W. H. Slager, *Chem. Eng. Progress* **43** (1947) pp. 335-42.

Features and performance of an absorption type recovery plant using various charging stocks are briefly described and critically compared. Flow sheets are given of Monsanto Chemical's plant at Texas City and the operation of the individual units of equipment is described. The composition of the streams at various points are given in tabular form. Ethylene-ethane separation diagram at 400 pounds pressure is given in equili-

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brium units and mols of reflux per mol of feed. Refrigeration requirements of the plant are given. Power operating conditions are summarized in a table.

Design and Use of Adsorptive Drying Units. R. C. AMERO, J. W. MOORE AND R. G. CAPELL, *Chem. Eng. Progress* **43** (1947) pp. 349-370.

A list of typical drying problems is given in tabular form and a summary of various methods of dehydration is also tabulated. The use of granular desiccants is of recent origin. Characteristics of solid desiccants are presented and the design of drying units to use them is considered. Drying costs are compared and data presented in tabular form. The relative drying efficiency of various common drying agents are compared in a table. The methods of determining moisture content are presented, including those that give an absolute measure of moisture content, as well as those that measure characteristics such as dew point, vapor pressure, or relative humidity. A bibliography of 126 references is included.

A Mechanism of Catalytic Cracking. R. C. HANSFORD, *Ind. & Eng. Chem.* **39** (1947) pp. 849-52.

The paper presents a study of the catalytic cracking of a simple paraffin, *n*-butane. It includes some new data on the exchange of deuterium and hydrogen between cracking catalysts and various classes of hydrocarbons. A mechanism for the catalytic cracking of hydrocarbons in the presence of typical catalysts of the silica-alumina type is proposed, based on the acceptance of protons from the hydrocarbon by adsorbed water and on the donation of protons to the hydrocarbon by the catalyst. Water-deficient catalysts have low cracking activity, and deuterium oxide adsorbed on cracking catalysts readily exchanges deuterium for hydrogen in adsorbed hydrocarbons at temperatures far below those required for cracking. The high concentration of protons on the surface of silica-alumina as compared to that on pure silica gel further substantiates the proposed mechanism. Catalytic cracking apparatus used in the work is described. The author believes that many other reactions, such as polymerization, hydrogen transfer, cyclization, alkylation, dealkylation of aromatics, etc., may be conceived as to proceed through ions formed as a result of proton exchange between the catalyst and the hydrocarbon. The formation of isoparaffins from higher paraffins and olefins probably occurs through intraionic rearrangement followed by splitting to an isoparaffin and hydrogen-deficient fragment. The fastest catalystic cracking reactions are those of hydrocarbons that are capable of forming a carbonium-type ion with a proton. Olefins and alkylaromatics are capable of forming such ions directly with the protons available at the catalyst surface, and hence silica-alumina catalysts are most effective in the conversion of these types of hydrocarbons. A bibliography of seven references is included.

Inhibition of Polymerization. M. S. KHARASCH, W. NUDENBERG, ELWOOD V. JENSEN, PAUL E. FISCHER AND DARWIN L. MAYFIELD, *Ind. & Eng. Chem.* **39** (1947) pp. 830-7.

In butadiene plants and in butadiene and styrene recovery units of the copolymer plants, monomers have formed hard benzene-insoluble material resembling popcorn. An outstanding characteristic of this popcorn polymer is its growth when exposed to monomers. The mechanism of this growth is discussed and various reasons are suggested for preventing the growth under plant conditions. Air and nitrogen dioxide treatments inactivate the seeds, and prevent the growth of the popcorn from the vapor monomers. It is also shown that under proper conditions a water solution of sodium nitrite is an outstanding inhibitor for the thermal polymerization of styrene and is far superior to the best organic antioxidants.

Initiation and Growth of Butadiene Resinous Polymers. L. M. WELCH, M. W. SWANEY, A. H. GLEASON, AND R. K. BECKWITH AND R. F. HOWE, *Ind. & Eng. Chem.* **39** (1947) 826-9.

The spontaneous formation of an insoluble, infusible butadiene popcorn polymer has been observed in some commercial distillation units that are used to purify butadiene for the synthetic rubber program. Once growth has started it has caused fouling and even bursting of large scale distillation equipment in a relatively short time. Although it can be initiated in many ways, iron and active oxygen play an important part in its formation. Growth is retarded but not terminated by vulcanization accelerators, but conventional antioxidants have little effect.

Solvent Extraction of Lubricating Oils. DR. H. TER MEULEN, *Trans. Institution of Chem. Engrs.* **21** (1943) pp. 1-10.

The article is a review of the refining of lubricating oils by solvent extraction. Approximate compositions of various crude residues are included and typical extraction diagrams are given. Requirements of an ideal solvent are listed. Processes using sulfur dioxide, furfural, phenol, chlorex and phenol-cresylic acids-propane are described and typical flow sheets presented.

A Study of the Corrosion of Copper-Alloy Condenser Tubes. N. W. MITCHELL, *Corrosion* **3** (1947) pp. 243-51.

Galvanic corrosion from copper alloys is rare in refineries. Stress-corrosion cracking is a common source of failure of brass alloys, especially when the metal is under stress in a corrosive atmosphere containing ammonia or a substitution product. The cracks are usually, but not always, intercrystalline; high-zinc brasses, that are over 15 percent, are most susceptible. Corrosion fatigue sometimes occurs in heat-exchanger or condenser tubes, as indicated by cracks in a surface roughened by corrosion. Impingement corrosion is resisted by cupronickel and aluminum brass. Alloys containing 85 percent or more of copper are practically unusable when sulfur attack is possible; alloys of admiralty metal are superior under these conditions, especially those alloys of lower copper content. Cupronickel is not generally satisfactory for handling sulfur compounds. The necessity of basing practice on field rather than laboratory observations is stressed.

Products: Properties, Utilization and Analysis

Spinning Band Column for High Vacuum Fractionation. S. F. BIRCH, V. GRIPP AND W. S. NATHAN, *Jour. Soc. Chem. Ind.* **66** (1947) pp. 33-40.

The authors note that the main objection to the use of any of the various types of packed columns and high vacuums is a relatively high pressure drop that exists between the still and the column head. To avoid decomposition when distilling compounds are of high molecular weight this pressure drop should be of the order of 0.1 mm. of mercury or less. Various types of columns that have been used and proposed are reviewed and discussed. The authors adapted a spinning band column to their purpose. It, with this auxiliary equipment, is described for operation at high vacuum such as 0.01-2.5 mm. of mercury. At atmospheric pressure the column is equivalent to 16.6 theoretical planes, and under vacuum conditions at a vapor rate of 300 ml./hr. it operates with a total pressure drop of only 0.04 mm. of mercury. Details of the column are presented in diagrammatic form and are described in some detail. Typical results are given in tabular and graphical form and a biblography of 17 references is included.

Nitrogen-Containing Organic Inhibitors of Corrosion. SHIH-JEN CH'IAO AND CHARLES A. MANN, *Ind. & Eng. Chem.* **39** (1947) pp. 910-9.

A quantitative relation between the cathode potential rise with the addition of inhibitor and its inhibition efficiency is suggested and demonstrated. Differences in functions between nitrogen-containing organic inhibitors and cathodic inorganic inhibitors is pointed out. The adsorption of nitrogen-containing organic inhibitor, although preferential or cathodic in nature, seems to follow Traube's law of adsorption. Long hydrocarbon chains of large monoaliphatic amines are inclined toward the metal surface at concentrations below a certain critical value. The angle of inclination varies with inhibitor concentration. The application of Langmuir's equation for monomolecular adsorption to the inhibition study was considered. The inhibition efficiency increases with the concentration of inhibitor in solution; greater solubility of saturated inhibitor which produces a higher concentration of onium ions in acid solution is the more useful and efficient inhibitor. The arrangement of the apparatus used for cathode and potential measurement is shown and described. The data are presented in considerable detail in 7 figures and 10 tables, and a bibliography of 28 references is included.

Benzonitrile Available For Research Investigation

Limited quantities of benzonitrile, a versatile chemical intermediate, have become available for study by research investigators and development engineers with announcement recently by the Socony-Vacuum Oil Company, Inc., of the placing in operation of a pilot plant for its manufacture.

Socony-Vacuum research experts predicted a wide usage of the material, which may be used in the production of synthetic resins, pharmaceuticals, and dyestuffs.

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Coarse Grind ....unscreened, 1 mesh and finer containing 25 to 35% finer than 20 mesh.

Coarse Screened . .same as above screened to remove 20 mesh and finer.

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Additional physical and chemical data on this important chemical are contained in Technical Data Sheet 714, sent when requested on your letterhead. Hooker's Technical Staff is also available for consultation and help on the application of Aluminum Chloride and the other Hooker chemicals to your purposes.

SPECIFICATIONS

Hooker Aluminum Chloride, Anhydrous $AlCl_3$

Gray, crystalline solid in three sizes.

Molecular Weight 133.3

ANALYSIS

Aluminum Chloride	98.5 % min.
Iron	0.05% max.
Non-sublimables in air at 950° C.	1.5 % max.

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Digest of Recently Issued United States

Patents Pertaining to Petroleum Refining

Compiled by HEINZ HEINEMANN

REFINING

U.S.P. 2,422,177. Process for Breaking Petroleum Emulsions. C. M. Blair, Jr., to Petrolite Corporation, Ltd.

Petroleum emulsions of the water-in-oil type are subjected to the action of a demulsifying agent. This agent is a sub-resinous esterified product of the formula:

$$(OH)_m (Y_{y'}X_{x'})_q \begin{matrix} /(COOH)_m \\ \backslash(COOZ)_{m'} \end{matrix}$$

where x' and y' represent whole numbers not greater than 5, and n,m,m' indicate the numeral 0 to 40; q is a small whole number not above 20; Z is a hydrogen ion equivalent; Y is an ester radical derived from an amino alcohol containing at least one occurrence of the radical

$$-(C_nH_{2n}) \begin{matrix} /RZ' \\ \backslash TZ' \end{matrix}$$

in which n represents the numeral 2 to 20, R and T are alkyl, alicyclic, alkanol or arylalkyl radicals, Z' represents hydrogen atoms or acyl radicals with not over 8 C atoms; and X is a carboxylic adduct radical. This adduct is an acyclic alpha-beta unsaturated acid with not over 10 C atoms combined with a non-conjugated, unsaturated, non-hydroxylated, fatty acid acyl radical with 8-32 C atoms at one intermediate point in the carbon chain of this radical. For example, an adduct prepared from linseed oil and maleic anhydride is treated with triethanolamine to obtain a demulsifier which is superior to customary demulsifiers.

U.S.P. 2,422,341. Solvent Extraction. W. W. Crouch to Phillips Petroleum Company.

Hydrocarbons of different degree of saturation are separated from a mixture containing them by contacting this mixture with a liquid di-tert-alkyl mercaptal under conditions which will permit selective solution of the less saturated compounds in this solvent. For example, a mixture of olefins and diolefins is treated with liquid acetoldehyde di-tert-butyl mercaptal to form an extract phase which will contain a major proportion of diolefins.

U.S.P. 2,422,484. Stabilized Xylidine. W. A. Herbst to Standard Oil Development Company.

Xylidine is stablized against discoloration during storage by an addition of 0.05-0.5%, preferable 0.2%, of para-thiocresol.

U.S.P. 2,422,515. Prevention of Corrosion in Ferrous Metal Pipe Lines Carrying Refined Petroleum Distillates. A. A. Anderson to Standard Oil Company of Indiana.

For controlling the internal corrosion of a ferrous metal pipe line which conducts a refined petroleum distillate containing dissolved water, an aqueous solution of an alkali amide is introduced into the distillate stream flowing through the line, the amount of amide thus added being not more than about 5 lbs. per 1000 barrels of distillate. This addition inhibits the corrosion resulting from the combined action of the distillate and a water phase separated therefrom.

U.S.P. 2,422,566. Hydrocarbon Fuels. W. A. Proell to Standard Oil Company of Indiana.

The patent describes a non-clogging fuel oil composition which comprises a normally liquid hydrocarbon fuel oil normally susceptible to cause clogging, in combination with 0.001-0.1% of a polyvalent metal soap and 0.005-0.05% of the condensation product obtained by reacting an aliphatic or aromatic aldehyde or ketone, or the like, with a polyalkylene amine with at least 3 amino nitrogen atoms at least two of which are primary nitrogen atoms. The polyvalent metal soap can, for example, be an aluminum soap, and the condensation product can be furfural triethylene tetramine.

U.S.P. 2,422,627. Process of Refining Hydrocarbon Mixtures. F. Martin, W. Gottschall and H. Velde vested in the Attorney General of the U. S.

Hydrocarbon mixtures are contacted, for the removal of impurities, at a temperature of 100-160° C. with an adsorbent catalytic material which had previously been used in the treatment of a similar olefin-containing hydrocarbon mixture at a temperature of 150-400° C. until its capacity of raising the octane number of this mixture was substantially exhausted. Resinous or coloring impurities are removed by this treatment from the hydrocarbon mixture to be refined. Spent fuller's earth can, for example, be used as the refining adsorbent material.

U.S.P. 2,422,822. Process for Breaking Petroleum Emulsions. C. M. Blair, Jr., to Petrolite Corporation, Ltd.

Petroleum emulsions of the water-in-oil type are subjected to the action of a demulsifying agent comprising an acid, ester, anhydrite, or salt adduct. This adduct is a condensation product of an acylic alpha-beta unsaturated acid with not over 10 C atoms combined at an intermediate point in the C atom chain of a non-conjugated unsaturated, non-hydroxylated, fatty acid acyl radical with 8-32 C atoms. This acyl radical is a constituent part of a salt, acid, or ester. An adduct of the indicated kind can, for example, be obtained by heating oleic acid, cottonseed oil, or linseed oil with maleic anhydride and neutralizing the product obtained with acqueous ammonia. The new demulsifiers are particularly useful in the treatment of emulsions at the bottom of an oil well.

U.S.P. 2,422,875. Process of Refining Hydrocarbons. P. H. W. Ågren to A. Johnson & Company.

Hydrocarbons are refined by contacting them with a catalyst which at least partly consists of aluminous cement having an Al_2O_3 content of at least 25%. The process is particularly useful for desulfurizing hydrocarbon mixtures.

U.S.P. 2,423,156. Method of Recovering Desirable Petroleum Hydrocarbon Fractions at Substantially Wellhead Pressure. L. S. Reid.

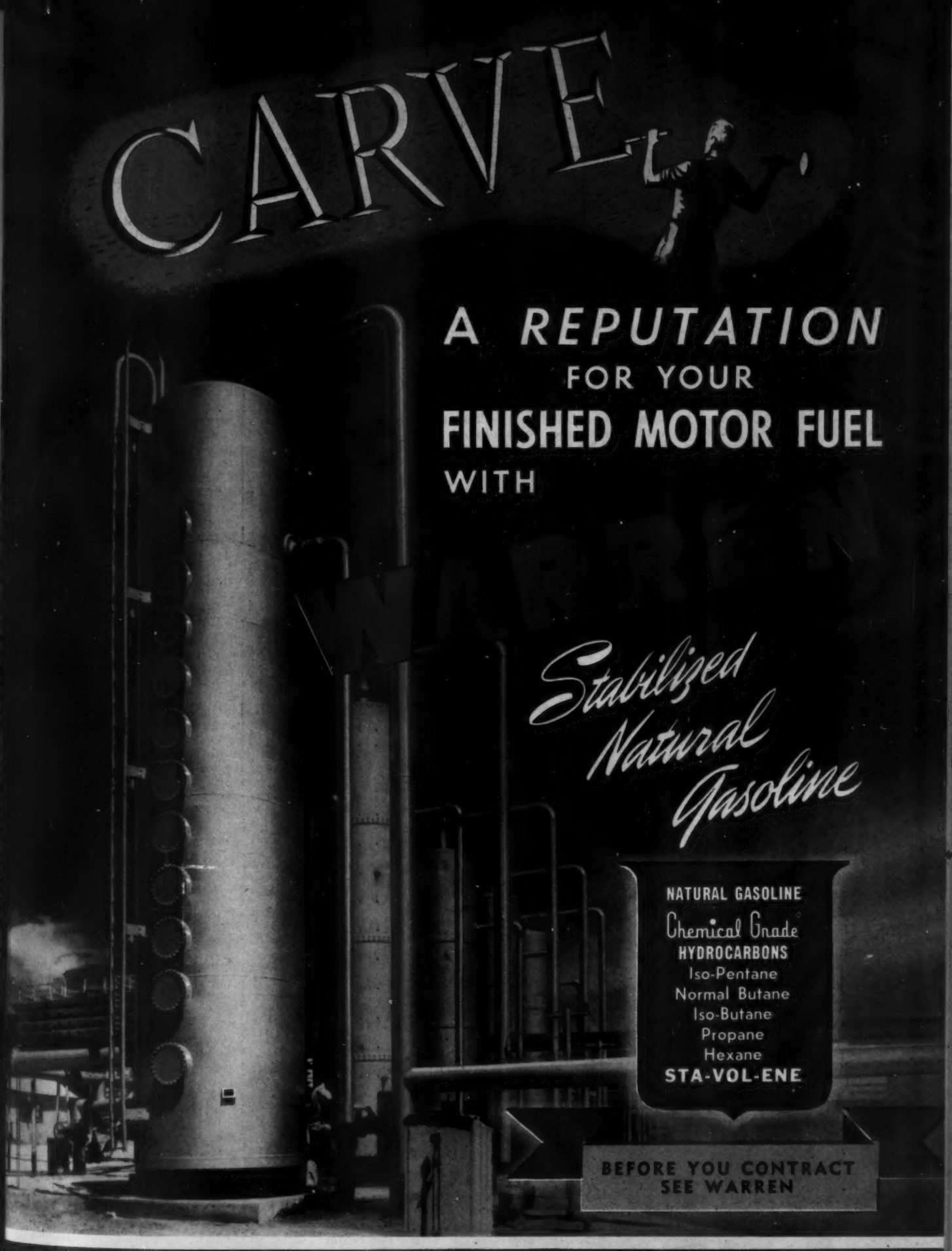
The patent relates to a process of recovering desirable liquefiable constituents from a distillate gas mixture, particularly from well gas, having an initial pressure at least as high as a pressure within the retrograde condensation range of the mixture. The distillate gas mixture is contacted with a heavy liquid hydrocarbon fraction to form a mixture which has a higher normal condensation pressure than the original gas mixture. The liquefiable constituents of this gas mixture are thereby liquefied. The resulting condensed constituents are separated into a relatively low boiling gasoline fraction and a relatively heavy liquid fraction. The latter is recycled as the contacting liquid.

U.S.P. 2,423,179. Recovery of Dienes by Polymerization and Depolymerization. T. F. Doumani, R. F. Deering and A. C. McKinnis to Union Oil Company.

Conjugated dienes with less than 7 C atoms are concentrated from hydrocarbon mixtures containing them by subjecting these mixtures to a temperatures of 600-1100° F. at increased pressure in the presence of an oxygen-bearing hydrocarbon derivative capable of accelerating dimerization of the dienes. Part of the dienes can be copolymerized simultaneously with olefins present in the charging mixture. Dimers and copolymers formed are separated from the residual material. A diene oxyde or olefin oxides can be employed as the oxygen-bearing material. The separated dimers, such as butadiene dimer, can be depolymerized to obtain concentrated dienes. The process is particularly useful for the treatment of hydrocarbon mixtures containing only 2-5% of the indicated dienes.

U.S.P. 2,423,364. Process for Breaking Petroleum Emulsions. C. M. Blair, Jr., W. Groves, and D. M. Schulz to Petrolite Corporation, Ltd.

Petroleum emulsions of the water-in-oil type are treated with a demulsifying agent which comprises a sub-resinous esterified adduct. This adduct is a complete ester, acid ester, or ester salt and an acylic alpha-beta unsaturated acid with not over 10 C atoms combined at an intermediate point in the C chain of a non-conjugated, unsaturated, non-hy-



SILVER ANNIVERSARY 25 YEAR 1947

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droxylated, fatty acid acyl radical with 8-32 C atoms. This esterfied adduct contains at least one occurrence of the radical —COO.(C_nH_mO)$_{m''}$Z' in which n represents the numerals 2-4, m'' the numerals 4-20, and Z' is an alkyl or acyl radical with not over 8 C atoms. For example, a polybasic alpha-beta unsaturated acid with not over 6 C atoms can be used in which the fatty acid acyl radical is a linolenyl or oleyl radical, Z is a hydrogen atom, n is 2 and m'' = 7-14.

U.S.P. 2,423,377. Determination of Diolefin Material in a Gaseous Mixture. B. Ferguson, Jr., to The United Gas Improvement Company.

For the determination of the proportion of diolefin material present in mixed gases which also contain a considerable proportion of other material of a density different from that of the diolefin material, the diolefin material is substantially completely and selectively removed from a portion of the mixed gases. Thereafter the ratio of the density of this treated portion to the density of the mixed gases from which said portion was taken is determined. This ratio may be employed in calculations to determine the diolefin content of the original mixed gases.

U.S.P. 2,423,388. Method for Purifying Styrene. C. W. Jordan to The United Gas Improvement Company.

Styrene containing impurities of phenylacetylene is emulsified with liquid ammonia by rapid agitation. Finely divided sodium is added to the emulsion at a temperature of —33° to 50° C. and under conditions insufficient to polymerize a large part of the styrene. A styrene of lower phenyl acetylene content is separated from the resulting mass.

U.S.P. 2,423,389. Process for Purifying An Aryl Olefin Having the Styrene Structure as a Nucleus. C. W. Jordan to The United Gas Improvement Company.

The process of this patent is similar to that of U.S.P. 2,423,388 and relates to the purification of aryl olefins with a styrene structure nucleus, such as styrene, alkylstyrenes, and the like, to remove acetylenic admixtures of similar b.p. which have a hydrogen atom attached to a C atom of a triple bond. A finely divided amide of an alkali metal or of a metal of groups IA or IIA of the periodic system is mixed with the contaminated compound.

U.S.P. 2,423,406. Petroleum Distillate and Method of Improving. E. T. Scafe and J. Herman to Socony-Vacuum Oil Company, Inc.

A light petroleum solvent or a highly aromatic hydrocarbon cracked distillate fraction which normally causes discoloration of a copper strip immersed in the boiling liquid for 30 minutes, is stabilized by mixing with the hydrocarbons an amount of 0.001-0.05% by weight of a compound of the general formula R-SH wherein R is an unsubstituted or alkyl substituted phenyl, naphthyl, or diphenyl radical, and wherein the S is linked to a nuclear C atom of this aromatic radical. Thiophenol is the preferred additive.

U.S.P. 2,423,412. Azeotropic Distillation of Other Aromatic Hydrocarbons from Styrene with Acetic Acid. E. H. Smoker to The United Gas Improvement Company.

Styrene is separated from a mixture with other hydrocarbons, particularly with o-xylene, by subjecting the mixture to distillation conditions in the presence of acetic acid. This additive can, for example, be employed in an amount of 0.2-5 parts of the acid per part of styrene mixture. A light oil styrene fraction with 50-60% styrene content can, for example, be subjected to azeotropic distillation in the presence of about 2 parts of acetic acid at a pressure of 100 mm Hg and at temperatures below 100° C. Styrene and o-xylene are separately recovered by water washing their separated acetic acid azeotropes.

U.S.P. 2,423,414. Process for Recovering Diolefins from Hydrocarbon Mixtures. F. J. Soday to The United Gas Improvement Company.

Diolefin material is separated from its mixture with monoolefin material, including isoolefins, (e.g. butadiene from its mixture with butenes including isobutylene), by contacting the mixture with absorption medium under such conditions of temperature that the diolefins and the monoolefins are absorbed. The mass obtained is subjected in a plurality of desorption stages to increasingly drastic conditions of desorption. At least one fraction containing substantial quantities of both diolefins and at least one fraction of relatively concentrated diolefin material is thus obtained. The first mentioned fraction is subjected to selective polymerization so that at least a preponderant portion of the monoolefins is polymerized, but without affecting a large portion of diolefin material. The polymerization products are separated from the resulting mixture, and an additional amount of relatively concentrated diolefin is obtained as the remaining portion of this mixture. A monovalent salt of Cu, Hg, or Ag can be used as the absorption medium.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,421,840. Cleaning of Contact Masses by Gaseous Suspension and Delivery Thereof to a Downwardly Moving Bed. C. H. Lechthaler and J. W. Payne to Socony-Vacuum Oil Company, Inc.

A particle form solid contact mass is passed cyclically through at least two zones in one of which it is maintained as a compact bed of downwardly gravitating particles while a gaseous atmosphere is maintained over the surface of this bed. A stream of contact material is directed onto the surface of the bed to replenish it, and a second stream of solid particles is directed into the upper section of an elongated vertical scrubbing zone located above the bed. This second stream is passed downwardly through the scrubbing zone as a freely falling stream of particles while a scrubbing gas is passed countercurrently through this falling stream to scrub therefrom undersized particles. This particle stream is directed from the lower end of the scrubbing zone as a confined stream of freely falling particles to a point of entry substantially below the surface of the bed of moving solid. The flow of the solid material in the bed immediately surrounding the point of entrance is deflected by baffles in such a manner as to enlarge the cross-sectional area of the stream to such an extent as to prevent any throttling action on the part of the bed on the free fall of the solid particles in the confined stream above the point of entry.

U.S.P. 2,422,172. Thermostable Catalysts for the Dehydrogenation of Hydrocarbons. A. E. Smith and O. A. Beeck to Shell Development Company.

The patent covers an adsorptive alumina compound suitable for use in catalysis, e.g. in the dehydrogenation of hydrocarbons. The compound has a specific surface of at least 40 square meters per gram and shows the X-ray diffraction pattern of a beta alumina of the general formula $3RO.16Al_2O_3$ wherein R is an alkaline earth metal. It is prepared by impregnating an adsorptive gamma alumina of the Haber system with 1-10% of an alkaline earth metal in the form of a compound which can be converted to the oxide by heating, such as calcium acetate. The mixture thus obtained is heated at a temperature of 950-1250° C.

U.S.P. 2,422,262. Apparatus for Contacting Solid Particles with Gaseous Fluids. B. B. Russell, 3d, to Standard Oil Development Company.

The apparatus according to this patent includes a cylindrical vessel, a centrally arranged circular perforated distribution plate in the lower portion of the vessel, and means for introducing gaseous fluid into the vessel for passage upwardly through the perforated plate. A skirt depends from the perimeter of this plate and concentric with it. A cylindrical baffle is arranged concentric with the wall of the vessel and with the skirt so that a plurality of annular concentric zones is formed into which a gaseous fluid can be introduced. A dense dry fluidized liquid-simulating mixture of contact particles and gaseous fluid is passing down through the annular zones wherein the contact particles are mixed with the gaseous fluid introduced into them. The apparatus is particularly used for the stripping of spent or contaminated catalyst following a hydrocarbon catalytic conversion process and allows a more complete stripping than was attainable heretofore.

U.S.P. 2,422,372. Preparation of an Alumina Supported Molybdenum Oxide Catalyst. A. E. Smith and O. A. Beeck to Shell Development Company.

A calcined adsorptive alumina is impregnated with a compound of an alkaline earth metal convertible to the oxide by heat in an amount equivalent to between 1 percent and 5 percent of the metal, and the impregnated material is calcined at a temperature of 600-900° C. A surface layer of the alkaline earth metal oxide is thus formed. This composite is then impregnated with a compound of Mo convertible to the oxide in an amount equivalent to between 4 percent and 15 percent Mo and in mol excess with respect to the alkaline earth metal. The thus formed composite is again calcined to form molybdenum oxide and cause reaction of the underlayer of alkaline earth metal oxide with a portion of the overlayer of molybdenum oxide. The catalyst thus obtained shows enhanced stability against loss of

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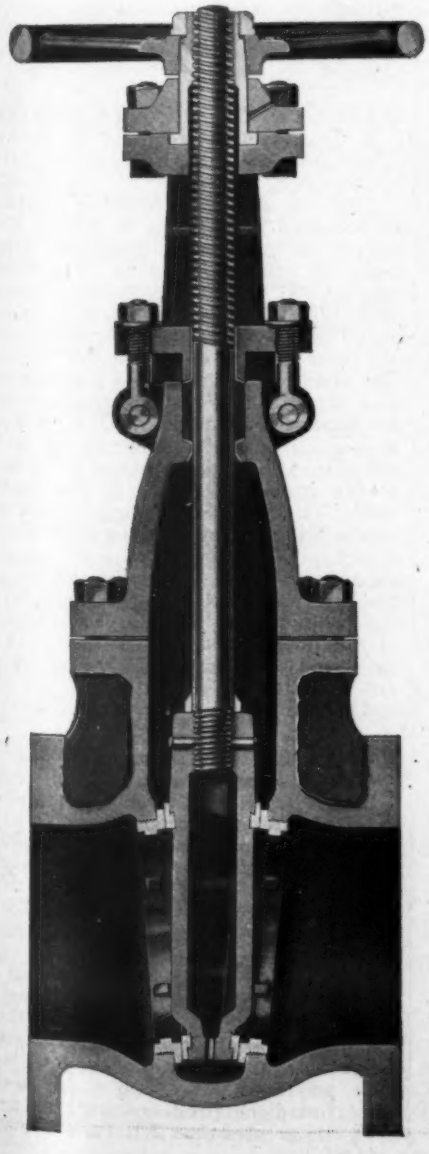

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activity upon heating at temperatures up to 800° C. It is particularly useful in dehydrogenation conversions.

U.S.P. 2,422,499. Alumina Gel. J. A. Pierce and C. N. Kimberlin, Jr., to Standard Oil Development Company.

Droplets of an alumina sol are suspended in a viscous organic water-immiscible inert liquid, such as petroleum oil, having dissolved therein an organic base non-reactive with this liquid, e.g. morpholine, in sufficient quantities, to change pH and induce gelation. The droplets are maintained in a quiescent state in suspension and out of direct contact with each other for a period of time until the alumina sol has set to a hydrogel. The hydrogel particles are separated from the viscous liquid and dried. Spherical particles of alumina gel are thus obtained in any desired size, e.g. in sizes of 0.25-5 mm. in diameter.

CRACKING AND REFORMING

U.S.P. 2,421,880. Oil Cracking Unit. N. O. Harmon.

The oil cracking unit comprises an elongated tube which can be externally heated, a hollow tubular member extending longitudinally inside this tube and spaced therefrom. Oil can be passed through the space between this member and the tube. The tube is adjustably mounted to vary the transverse dimensions of this space.

U.S.P. 2,422,790. Method of Coking Oils. R. Lee, H. D. Noll, and V. A. Kalichevsky to Socony-Vacuum Oil Company, Inc.

Charging stock for catalytic cracking is prepared by heating a petroleum charge stock to a temperature sufficient to cause distillation to dryness, e.g. to 900° F. under increased pressure. The thus heated stock is introduced into a vertically elongated chamber near the top for free fall therein. The chamber is maintained substantially free of combustion supporting gas and products of combustion. A flowing stream of granular contact mass is introduced into the chamber below and in the pass of the fall of the heated stock. The stream of contact mass receives the stream of charging stock within the chamber in such a manner that the vaporization takes place with the deposition of coke substantially wholly upon the contact mass without the alteration of the flow characteristics thereof. Vapors and coke carrying contact mass are separately removed from the top and bottom, respectively, of the chamber.

U.S.P. 2,423,374. Process for Producing Aromatics and Diolefins from Petroleum. N. K. Chaney to The United Gas Improvement Company.

Petroleum oil is passed in vapor phase through a heated pyrolyzing path where it is pyrolized in the presence of a diluent gas. Conjugated diolefins of 4-5 C atoms including butadienes and aromatic hydrocarbons including benzene are formed with an intensity of pyrolysis at least sufficient to cause the production of at least 20 cubic feet of residual oil gas per gallon of oil pyrolized and insufficient to cause the ratio of the total benzene produced per gallon of oil to the total butadiene produced per gallon of oil to be greater than 2:1. Paraffin mate-

rial of b.p. similar to that of the aromatic hydrocarbons is simultaneously produced. Conjugated diolefins of 4-5 C atoms are separated from the product mixtures. At least a portion of the remaining products is subjected to vapor phase pyrolysis in a second pyrolyzing path under conditions of such intensity that an olefin free fraction separated from the products of this second pyrolysis and boiling within 3° in the range 107.5° C. and 112.5° C. has a paraffin content of less than 4 percent by volume. Aromatic hydrocarbons relatively free from paraffinic contamination of similar b.p. are separated from the products of the second pyrolysis.

U.S.P. 2,423,375. Production of Dienes, Resin-Forming Aromatic Hydrocarbons and Non-Resin-Forming Aromatic Hydrocarbons. N. K. Chaney and E. L. Hall to The United Gas Improvement Company.

A petroleum oil below 5 in classification of the Bureau of Mines Index and with an average b.p.-density-mean dispersion evaluation factor not higher than 68 as determined by the formula: Evaluation factor

$$=\left[156\text{-}492\left(\text{loglog}\frac{\text{Average b.p. ° F.} - 114}{\text{d } 20/4 \times 10^3 - 70.7}\right)\right]$$

$$\left[1004\left(\sin \text{arc tan}\frac{\text{Average b.p. ° F.} - 160}{H_{F\text{-}C} \times 10^4 - 65}\right) - 906\right] \times 10^{-3}$$

in which d 20/4 is the density of the oil at 20° C. as compared with water at 4° C. and $H_{F\text{-}C}$ is the mean dispersion of the oil employing the F and C spectral lines, or fractions of this oil are pyrolyzed in a cyclic process in the presence of a readily condensable diluent gas in a gas-making path in which heat is stored by the passage of hot blast gases. The pyrolysis is conducted in such a manner that any blue water gas is restricted to less than about 35 cubic feet per gallon of petroleum oil pyrolyzed as measured at a pressure of 760 mm. Hg at a temperature of 60° F. Temperature, time of contact, length, and distribution of the cycle employed for the pyrolysis are adjusted so that the volume of residual oil gas produced per gallon of petroleum oil pyrolyzed falls within the range of 40-80 cubic feet at a pressure of 760 mm. Hg and a temperature of 60° F., and in such a manner that the relationship between the sulphonation residue and the free C obtained is within the sulphonation-free C relationships lying to the left of and below the curve defined by the equation $X^3(Y-0.03) = 0.35$ in which X and Y are rectangular coordinates of free C expressed in % by weight of the original oil pyrolyzed and sulphonation residue expressed in % by volume of this oil, respectively. Dienes together with resin-forming and non-resin-forming aromatics, particularly benzene, toluene, xylene, and styrene are obtained by this cyclic process.

ISOMERIZATION

U.S.P. 2,422,233. Isomerization Process. O. Gerbes to Standard Oil Development Company.

A mineral oil is introduced into a reaction vessel with exposed metal surfaces and forms an oil film on the metal surfaces. The oil film is maintained at a temperature of 150-300° F. while a vaporized aluminum halide is introduced into the vessel in an excess amount over that required to react with the oil. The aluminum halide vapors are maintained in contact with the oil film until a tenacious coating of carbonaceus material is deposited on surfaces within the vessel. A hydrocarbon feed stock is subsequently introduced to the reaction vessel and reacted therein with the excess aluminum halide present. The process is preferably employed in the isomerization of normal paraffins. Corrosion of the exposed metal surfaces of the vessel is prevented by the carbonaceous coating thereon.

U.S.P. 2,422,346. Isomerization Process. G. L. Farrar to Socony-Vacuum Oil Company.

Normal butane is maintained in intimate contact with an $AlBr_3$ catalyst promoted by free O_2, the amount of $AlBr_3$ dissolved in the hydrocarbon being between 2.1-2.85 mol% of the solution. The solution is maintained at a temperature of 210-240° F. Isobutane is obtained.

U.S.P. 2,422,884. Isomerizing Olefins Using Boric Oxide on Alumina as Catalyst. J. Burgin to Shell Development Company.

Olefinic compounds such as butylene or amylene, are imoserized in the presence of a catalyst which consists of an adsorptive alumina obtained by partial dehydration of an alumina trihydrate crystallized from an alkali aluminate solution and having incorporated on the available surface between 1.5×10^{-4} and 9.5×10^{-4} grams of B_2O_3 per square meter. The new catalyst is exceptionally active in accelerating the isomerization of olefinic materials, is easy to manufacture and of refractive nature, so that it retains its activity over extended periods of time under conditions of high temperature during use and regeneration.

ALKYLATION

U.S.P. 2,422,349. Alkylation of Hydrocarbons. F. E. Frey to Phillips Petroleum Company.

An intimate liquid mixture of alkylatable hydrocarbon and liquid alkylation catalyst (e.g. HF) is passed to a pipe coil comprising a series of horizontal pipes in a vertical row joined at the ends to form a continuous upwardly rising coil. The mixture is added at the bottom of the coil and flows upwardly through it at a rate of at least 2 feet a second and sufficient speed to obtain and maintain intimate mixing of the liquid hydrocarbons and the liquid catalyst. An olefin-containing material is added at a series of points along the length of the coil in an amount at each point such that the ratio of unreacted alkylatable hydrocarbon to unreacted olefin is progressively higher at successive points in the direction of flow of the mixture. Water is sprayed over the outside of the coil, and air is forced over this outside either concurrent or countercurrent to the flow of reactants through the coil and countercurrent to the flow of sprayed water. The resulting reaction mixture is passed from the top of the coil and an alkylate fraction is recovered therefrom. Isobutane can, for example, thus be alkylated with butylenes.

U.S.P. 2,423,401. Alkylation of Isoparaffins. A. O. O'Kelly, R. H. Work, and J. Plucker, III, to Socony-Vacuum Oil Company, Inc.

A branched chain paraffin hydrocarbon is alkylated with an olefin in the presence of less than 1 percent by weight, based on hydrocarbons charged, of phenol, an alkylated phenol, an amino phenol, or combinations thereof. Branched-chain hydrocarbons of high anti-knock rating, boiling in the gasoline range are thus synthesized. Polymerization is suppressed by the phenol additive. The usual alkylation catalysts, such as conc. H_2SO_4 or a Friedel-Crafts type catalyst, can be utilized with the phenol additive.

POLYMERIZATION AND CONVERSION

U.S.P. 2,421,936. Production of Octenes. V. Haensel and V. N. Ipatieff to Universal Oil Products Company.

A non-tertiary olefin of at least 4 C atoms, such as n-butylene, is absorbed in a first step in a mineral acid polymerizing catalyst, e.g. H_2SO_4 of 60-85 percent concentration. In a second step at tertiary alcohol, such as tert, butylalcohol, is introduced in free unabsorbed form to the mineral acid catalyst the absorbed olefin. The alcohol is reacted with the absorbed olefin in the absence of unabsorbed olefin. The resultant hydrocarbon polymers, e.g. 2,2,3- and 2,3,4-trimethylpentenes, are separated from the catalyst.

U.S.P. 2,421,946. Polymerization of Olefinic Hydrocarbons. V. N. Ipatieff and C. B. Linn to Universal Oil Products Company.

Olefinic hydrocarbons are polymerized in the presence of BF_3 and fluorosulfonic acid to form hydrocarbons of higher mol weight, e.g. such of 6-10 C atoms. Temperatures of —50 to 250° C. can advantageously be used. The addition of fluorosulfonic acid to the BF_3 catalyst causes normally liquid hydrocarbons to be produced by polymerization of normally gaseous olefins instead of the usually obtained elastomers.

U.S.P. 2,421,950, 2,421,951. Polymerization of Olefinic Hydrocarbons. C. B. Linn to Universal Oil Products Company.

Olefinic hydrocarbons with at least 3 C atoms are polymerized according to U. S. patent 2,421,950 in the presence of a catalyst comprising a major proportion of liquid HF having dissolved therein a minor proportion by weight of fluorides or oxy-fluorides of S, Se, N, P, Mo, Ti, W, V, or Si boiling below 300° C. Polymers with 6-12 C atoms and boiling in the gasoline range are produced. They are useful as blending stock with straight-run gasoline to increase its antiknock value.

According to U. S. patent 2,421,951 a substantially non-oxidizing compound consisting of acids of phosphorus, or their anhydrides, or esters is employed as the additive to the HF catalyst.

U.S.P. 2,422,002. Neutral, Highly Unsaturated Polymer Composition and Method for Producing Same. W. E. Elwell and N. W. Furby to California Research Corporation.

A thermally reformed naphtha is

treated with H_2SO_4 to polymerize its unsaturated compounds. The resulting acid sludge is separated. The remaining oil layer is neutralized. Components boiling in the gasoline range are distilled off from this neutralized remainder. The residuum is then reduced under a vacuum of above 25 inches Hg and steam at temperatures not over 450° F. to produce polymers with Iodine numbers of 160-225.

U.S.P. 2,422,163. Catalytic Conversion of Aromatic Compounds. J. K. Dixon to American Cyanamid Company.

A paraffin having at least 2 C atoms and having 2 aryl substituents attached to one of its C atoms is heated at a temperature which will cause the decomposition of the paraffin into a plurality of aromatic compounds in the presence of a catalyst. In the case of a natural bauxite or a titania-alumina-silica catalyst a temperature of at least 350° C. is required. If, for example, an asymmetric diarylethane is to be treated, the time of contact with the catalyst can be 0.001-0.4 second. A diluent, such as water vapor, can be mixed with the charge material.

U.S.P. 2,422,164. Catalytic Method of Producing Aromatic Compounds. J. K. Dixon to American Cyanamid Company.

The process of this patent differs from that of U. S. patent 2,422,163 essentially only in that a zirconia-alumina-silica catalyst is employed.

U.S.P. 2,422,165. Production of Aromatic Compounds. J. K. Dixon to American Cyanamid Company.

The process of this patent differs from that of U. S. patent 2,422,163 essentially only in that a thoria-alumina-silica catalyst is employed.

U.S.P. 2,422,166. Process of Producing Aromatic Compounds. J. K. Dixon and D. R. May to American Cyanamid Company.

The process of this patent differs from that of U. S. patent 2,422,163 essentially only in that a zirconium oxide catalyst is employed.

U.S.P. 2,422,169. Production of Aromatic Compounds. D. R. May and J. K. Dixon to American Cyanamid Company.

The process of this patent differs from that of U. S. patent 2,422,163 essentially only in that a titanium oxide catalyst is employed.

U.S.P. 2,422,171. Method of Producing Aryl Compounds. K. W. Saunders to American Cyanamid Company.

The process of this patent differs from U. S. patent 2,422,163 essentially only in that a magnesia-alumina-silica catalyst, such as Attapulgus clay, is employed.

U.S.P. 2,422,318. Production of Aromatic Compounds. M. G. Sturrock and T. Lawe to Dominion Tar & Chemical Company, Ltd.

A paraffin having at least 2 C atoms and having 2 aryl substituents attached to one of those C atoms is heated to a temperature (of at least 350° C.) which will cause decomposition of this compound into a plurality of aromatic compounds in the presence of a catalyst consisting of a metal silicate whose metal belongs to group IV (a) of the periodic table, e.g., zirconium silicate. Mononuclear aromatics are obtained by the treatment of asymmetric mononuclear diaryl ethanes.

U.S.P. 2,422,501. Apparatus for Carrying Out Chemical Reactions in the Presence of Finely-Divided Powder. B. E. Roetheli to Standard Oil Development Company.

The apparatus according to this patent is used in processing gaseous material, such as hydrocarbon gases and vapors, at high temperatures for short reaction periods. The apparatus comprises a vertical reaction chamber, a conduit for introducing the gases to be treated at one end of the chamber, a separate conduit for introducing a stream of hot powder into the chamber, and a third conduit connected with the opposite end of the chamber for withdrawing a mixture of powder and gaseous products from the chamber. Adjacent to this last named end of the chamber means are provided for separating powder from gaseous products. A cooling medium is injected into the gaseous reaction products immediately after their separation from the powder. The separated powder is heated in a separate chamber to a temperature materially above that maintained in the reaction chamber. The heated powder is transferred through the above named separate conduit which is in open communication with the heating chamber, directly to the reaction chamber. A plurality of fixed orifices is arranged at spaced points within this separate conduit adapted to restrict the passage of powder between the heating chamber and the reaction chamber. A sealing gas can be introduced between these orifices.

U.S.P. 2,422,692. Conversion of a Normally Gaseous Olefin Other than Ethylene to Isobutane. W. J. Mattox to Universal Oil Products Company.

A hydrocarbon fraction containing ethylene and a higher mol weight normally gaseous olefin, such as a mixture of ethylene with propylene or butylene, is treated with a solid polymerizing catalyst comprising silica and phosphoric acid, or alumina, or thoria, or titania, or zirconia, in the presence of a non-olefinic liquid hydrocarbon diluent at a temperature of 200-500° C., a weight hourly space velocity of 0.5-20, and a pressure of 100-1000 psi. The weight ratio of non-olefinic liquid hydrocarbon to the normally gaseous olefin is maintained at not less than 1:1.

U.S.P. 2,422,791. Endothermic Catalytic Conversion of Hydrocarbons. F. W. Leffer to Universal Oil Products Company.

Hydrocarbons are continuously endothermically converted in contact with subdivided solid catalyst in a reaction zone. Contaminated catalyst is regenerated by burning carbonaceous matter in a regenerating zone. Resultant hot combustion gases are separated from the regenerated catalyst. The latter is returned to the reaction zone. Fresh combustion gases are mixed with the combustion gases from the regenerating zone and the resultant mixture is contacted with a solid heat retentive material. The thus heated material is contacted with a fluid heat transfer medium. The thus heated fluid medium is introduced to the reaction zone to supply heat for the endothermic conversion reaction.

U.S.P. 2,422,793. Conversion of Fluid Hydrocarbons. J. McAfee to Universal Oil Products Company.

In a process wherein a bed of subdivided solid contact material is maintained in each of a plurality of confined zones between and through which it is continuously circulated and in at least one of which it accumulates volatile fluid undesirable for transmission with the solid particles to the other confined zones, the stream of solid particles being transferred from the one confined zone to the other is purged of the undesirable fluid. For this purpose a stream of the solid particles and accumulated fluid is directed from a point below the upper extremity of the bed in one zone into a separate stripping zone where the solid particles are caused to fall downwardly through a free space counter-current to an ascending stream of stripping fluid. A substantially lower solid particle concentration is maintained in said free space than prevails in the bed in the zone in question. The stripping fluid together with the undesirable fluid is then removed from the stripping zone. The purged solid particles are passed downwardly in the form of a relatively dense column into a stream of transporting fluid wherein they are suspended. The suspension obtained is directed into the other confined zone. The height of the relatively dense column is maintained constant by controlling the rate at which solid particles are supplied from the bed into the stripping zone in response and in inverse relation to minor variations in the height of the column. The process is, for example, useful in the cracking of hydrocarbon oil.

U.S.P. 2,422,798. Hydrocarbon Reactions in the Presence of Aluminum Halide-Olefinic Ketone Complexes. H. Pines to Universal Oil Products Company.

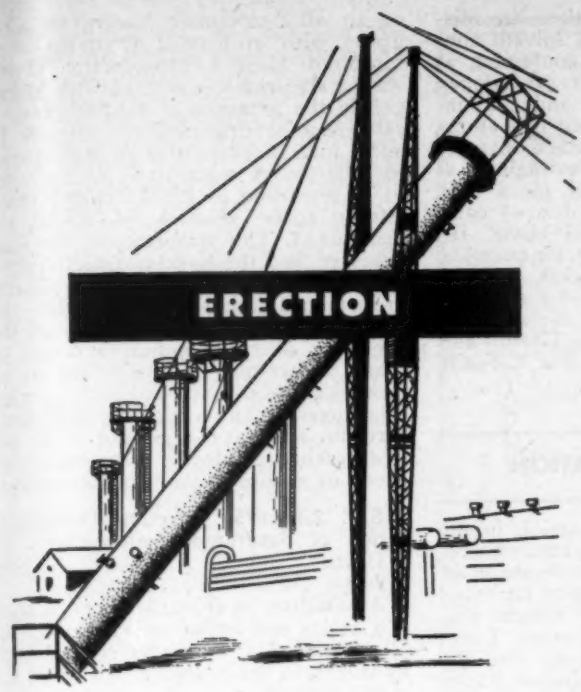
A hydrocarbon is reacted at conversion conditions in the presence of a catalyst which is formed by interacting at least 1, but not more than 3 mol proportions of $AlCl_3$ or $AlBr_3$ with an olefinic ketone, such as mesityl oxide. The process is, for example, useful in the alkylation, dealkylation, and isomerization of hydrocarbons.

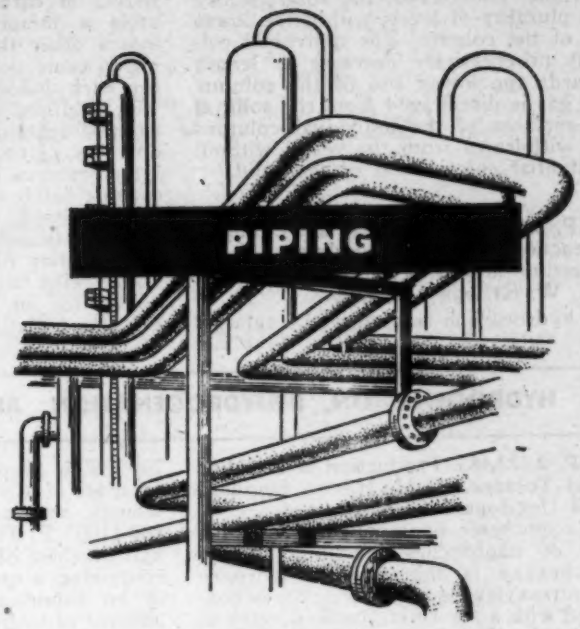
U.S.P. 2,422,991. Production of Hydropolymers. L. C. Strang to Anglo-Iranian Oil Company, Ltd.

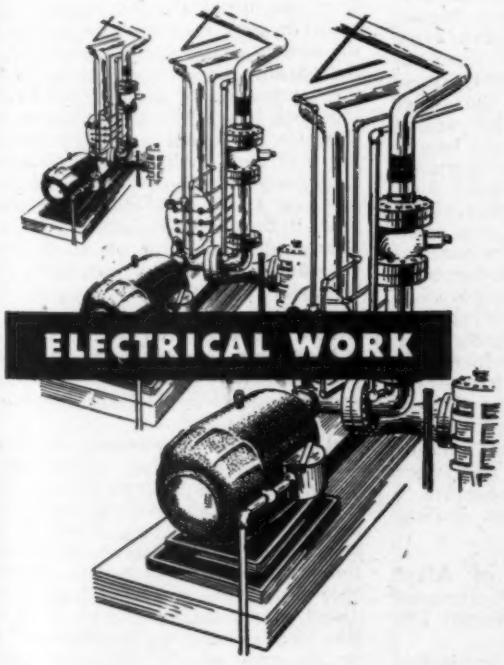
An olefinic feed stock comprising n-butenes and isobutene in a ratio of between 1.5:1 and 2.5:1 and propene in a proportion of 60-130% by wt. of the isobutene content of the feed stock is catalytically polymerized at a temperature of 160-190° C. Polymer products obtained are subjected to non-destructive catalytic hydrogenation. If a pressure of 250-1400 psi. is employed in the polymerization, the product obtained by subsequent hydrogenation will have an octane number of not less than 90. The polymerization catalyst can, for example, consist fo copper phosphate, cadmium phosphate and phosphoric acid, and the hydrogenation catalyst can be a nickel-tungsten sulfide catalyst.

U.S.P. 2,423,013. Method and Apparatus for Contacting Gases with Particle Form Solid Materials. L. P. Evans to Socony-Vacuum Oil Company.

A particle form solid contact mass is moved through a confined reaction zone as a compact column of downwardly flowing particles while gaseous hydrocarbons are passed at conversion conditions longitudinally and concurrently through this particle column. The flow of gases near the lower end of this column is baffled so as to cause it to







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flow in an upwardly sloping direction through a plurality of relatively short individual columns of the solid formed at a plurality of levels within the lower end of the column. The individual columns progressively decrease in length towards the lower end of the column. The gas is disengaged from the solid at the surfaces of the individual columns and withdrawn from the vessel without substantial entrainment of the solid.

U.S.P. 2,423,045. Liquid Phase Catalytic Reactions of Hydrocarbons. H. J. Passino and J. S. Rearick to The M. W. Kellogg Company.

A hydrocarbon reactant and a catalyst immiscible with one another are dissolved in a normally liquid solvent consisting of carbon halides containing at most a minor proportion of halogen atoms other than fluorine and containing in each molecule at least 6 F atoms for each halogen atom other than F. The solution formed is maintained at suitable reaction conditions for a time effective to complete the desired catalytic reaction in the liquid phase. Inorganic halide catalysts can, for example, be employed in the process for the isomerization of paraffins, for effecting condensation of olefins, or for cracking high-boiling hydrocarbons. Useful solvents are, for example, C_7F_{16}, $C_6F_{12}Cl_2$, $C_7F_{12}H_4$, $C_7F_{12}Cl_2H_2$.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,422,485. Production of Xylidine and Toluene. R. M. Hill to Standard Oil Development Company.

A naphthenic naphtha containing 60-70% of naphthenes including methyl cyclohexane is mixed with hydrogen and nitroxylene, and the mixture is contacted with a reforming catalyst, such as an alumina-molybdenum oxide catalyst, at a temperature of 850-950° F. and under a pressure of 200-300 psi. The methyl cyclohexane is thereby converted to toluene and the nitroxylene to xylidine. The reaction products are fractionally distilled to recover toluene, xylene and xylidine separately. A portion of the xylene is subjected to nitration and the nitrated xylene is recycled to the reforming operation. The amount of nitroxylene added to this operation is preferably such as to provide by its exothermic hydrogenation a substantial portion of the total heat required for the endothermic reforming of the methyl cyclohexane.

U.S.P. 2,422,670. Selective Demethylation of Paraffinic Hydrocarbons. V. Haensel and V. N. Ipatieff to Universal Oil Products Company.

A paraffin containing a quaternary C atom and having attached thereto an alkyl radical of at least 2 C atoms is commingled with hydrogen in a ratio of at least 1.6 mols of hydrogen per mol of the paraffin. The mixture is reacted in the presence of a hydrogenating catalyst, such as a metal of the iron group, at a temperature of 175-375° C. and under pressure of from atmospheric to 300 atm. The terminal methyl group of the alkyl radical of the paraffin is replaced by hydrogen. The reaction is terminated prior to the splitting from the paraffin molecule of an alkyl group of more than one C atom and prior to scission of any of the bonds of the quaternary C atom. A demethylated paraffin having the quaternary C atom configuration is thus obtained. When 2,2,3-trimethylpentane is employed as the starting material, the end methyl radical not attached to either the quaternary of the tertiary C atoms is removed and triptane is formed.

U.S.P. 2,422,671. Process for Lowering the Molecular Weight of Nonaromatic Hydrocarbons. V. Haensel and V. N. Ipatieff to Universal Oil Products Company.

The process of this patent is similar to that of the U. S. patent 2,422,670. An aliphatic hydrocarbon containing a quaternary C atom is employed as the charge material. A temperature of 300-700° F. is used for the reaction in the presence of a Ni-containing catalyst previously reduced at a temperature of 800-1100° F. The product is a saturated hydrocarbon of lower mol weight also containing a quaternary C atom. There is no minimum requirement for the amount of hydrogen to be added. Naphthenic hydrocarbons can be treated in the same manner.

U.S.P. 2,422,672. Selective Demethylation of Trimethylpentanes to Form Triptane. V. Haensel and V. N. Ipatieff to Universal Oil Products Company.

An isooctane fraction comprising 2,2,-4-, 2,2,3-, 2,3,4-, and 2,3,3-trimethylpentanes and higher boiling compounds is fractionated to remove these higher boiling compounds. The remaining trimethylpentanes are further fractionated to separate 2,2,4-trimethylpentane from a fraction comprising the other trimethylpentanes. This fraction and a hydrogen fraction are separately heated to a selective demethylation temperature and then mixed. The heated mixture obtained is contacted with a nickel catalyst at about 500° F. and at a pressure of about 500 psi. The pressure of the products of this demethylation is reduced to about 200 psi. to separate a hydrogen fraction which is recycled to the demethylation. The pressure of the products is then further reduced to about 70 psi to separate a methane fraction. The remaining products are fractionated to separate an overhead fraction containing 2,2- and 2,3-dimethylbutanes from higher boiling products. The latter are further fractionated to separate a triptane fraction from higher boiling trimethylpentanes.

U.S.P. 2,422,673. Treatment of Alkyl Aromatic Hydrocarbons. V. Haensel and V. N. Ipatieff to Universal Oil Products Company.

The process of this patent is similar to that of U.S. Patent 2,422,670. An aromatic hydrocarbon having an alkyl side chain of at least 2 C atoms is here employed as the starting material. The demethylation reaction is performed at a temperature of 3560-650° F. and at a pressure not exceeding 1000 psi. At least one methyl group is removed from the side chain. An ethyl benzene is thus obtained from a propyl benzene.

U.S.P. 2,422,674. Selective Demethylation of Saturated Hydrocarbons. V. Haensel and V. N. Ipatieff to Universal Oil Products Company.

A paraffin with more than 4 C atoms, or an alkyl aromatic having an alkyl group with at least 2 C atoms, or a saturated alkyl hydroaromatic having such a side chain is reacted with hydrogen in the presence of a hydrogenation catalyst at a temperature of 350-750° F. and a total pressure of from atmospheric to 3000 psi. A molar ratio of hydrogen to hydrocarbon of 1.7-11.2 and a liquid hourly space velocity of 0.5-8.0 are maintained. The temperature, the total pressure, and the hydrogen partial pressure are chosen on the basis of a directly proportional relationship between the temperature and the logarithm of the pressures over the indicated ranges so that a higher temperature within the indicated range is employed with a higher total pressure and a higher partial pressure to effect the splitting from the hydrocarbon employed of only a methyl group or groups in the form of methane.

U.S.P. 2,422,675. Selective Demethylation of Saturated Hydrocarbons. V. Haensel and V. N. Ipatieff to Universal Oil Products Company.

A paraffinic hydrocarbon with at least 5 C atoms and including an alkyl group of at least 2 C atoms is reacted with hydrogen in the presence of a Ni or Co metal catalyst at a catalyst temperature of 150-385° C. defined by the equation: $T = 0.26\ [T_{CR} - 100] + k \log_{10} [(14.7 P)^{2.00} (SV)^{1.24} C]$ where T = catalyst temperature in ° C.; T_{CR} = a temperature from 425-650° C. at which the catalyst was previously reduced; k = 18.4-23.3 at an initial absolute partial pressure of hydrogen above 3.45 atm.; k = 25-30.7 at an initial absolute partial pressure of hydrogen below 3.45 atm.; P = the initial absolute partial pressure of hydrogen in atmospheres; (SV) = the hourly liquid space velocity at which the paraffinic hydrogen is charged; C = the conversion of the charged hydrocarbon into lower boiling saturated hydrocarbons expressed as % by volume of the charged hydrocarbon. Neopentane can, for example, be produced by this process from neohexane. Cycloparaffinic hydrocarbons with at least 8 C atoms and including an alkyl group of at least 2 C atoms can also be demethylated by this process.

U.S.P. 2,422,802. Dehydration of Diacetone Glycol to Form a Methyl Pentadiene. W. T. Schelling and J. Anderson to Shell Development Company.

Acetone is condensed to diacetone alcohol which is then catalytically hydrogenated to diacetone glycol. The latter is catalytically dehydrated to methyl pentadiene by heating it in the liquid phase and in the presence of a dehydration catalyst, e.g., of iodine, under suitable conditions in a dehydration zone in direct communication with a fractionation zone. Water is continuously added to the top of the fractionation zone while distilling therefrom an overhead distillate comprising the desired methyl pentadiene, unsaturated alcohol intermediate, ether by-products, light ends, water and ether by-products from the unsaturated alcohol intermediate. The unsaturated alcohol intermediate is recycled to the dehydration zone.

U.S.P. 2,423,029. Process for Producing Olefins. E. J. Houdry to Houdry Process Corporation.

A paraffin hydrocarbon with 4-5 C atoms is dehydrogenated in the presence of a bed of suitable catalyst under such conditions that the corresponding olefin

is obtained practically as the only product. The bed of catalyst is subjected to a recurring cycle wherein it is alternately contacted with aliphatic hydrocarbon charge including said paraffin and regenerated by burning off deposit. The contacting portion of this cycle is effected under conditions such that the catalyst bed supplies heat of conversion of the charge with resultant progressive decrease in catalyst temperature within a range throughout which there is substantial dehydrogenation of the charge, and the regenerative portion of the cycle is effected under conditions such that the heat resulting from the regeneration of the catalyst bed is retained by the latter with the resultant increase of its temperature substantially compensating for the preceeding temperature loss. During the contacting portion of the cycle an olefin of the same number of C atoms is charged together with and in addition to the paraffin. This olefin is dehydrogenated under the operating conditions and, in addition to the corresponding diolefin, a coky deposit is obtained which is in excess of the amount required to restore during regeneration of the catalyst bed the heat lost during conversion of the olefin. The proportion of olefin to paraffin is controlled so that the total coky deposit produces upon burning and stores within the catalyst bed substantially the amount of heat required in the conversion of the total charge.

U.S.P. 2,423,163. Conversion of Hydrocarbons. C. L. Thomas to Universal Oil Products Company.

Hydrocarbons boiling above the gasoline range, are converted in the presence of a mechanical mixture of a porous supporting material, such as gamma alumina, and sublimed molybdenum oxide. Hydro forming or dehydrogenation can, for example, be carried out with this catalyst at 800-1200° F.

U.S.P. 2,423,328. Process for Cyclizing Hydrocarbons. E. T. Layng to The M. W. Kellogg Company.

Paraffinic hydrocarbons within the gasoline boiling range are contacted with a dehydrogenation and cyclization catalyst at a suitable temperature and space velocity, e.g., at a temperature of 875-1025° F. and at a pressure of 30-450 psi., in the presence of 0.5-8 mols of added hydrogen per mol of hydrocarbon. The contact is effected in a plurality of successive stages. The reaction products from the first stage are treated in an intervening stage to eliminate olefins therefrom by catalytically hydrogenating them to paraffins prior to their passage to the second stage. Superior motor fuel can thus be obtained from paraffinic naphtha.

U.S.P. 2,423,418. Process for Producing Alkadienes by Dehydrogenating Alkenes. C. M. Stone and K. J. Korpi to The Texas Company.

Alkadienes are produced from alkenes, e.g., 1,3-butadiene from n-butene, by passing into a reaction zone maintained at a temperature of 800-1300° F. and in contact with an alumina catalyst containing a minor proportion of $CuSO_4$, a gaseous mixture of an alkene, SO_2 and steam. The sum of the partial pressures of alkene and SO_2 in this mixture shall be substantially below one atmosphere, preferably below 0.85 atm. At least 1 mol of steam and at least 0.1 mol of SO_2 (e.g. 0.25-1.0 mol) shall be contained in the gaseous mixture per mol

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of alkene. The SO_2 works as a hydrogen acceptor or secondary reactant in this process.

DESULFURIZATION

U.S.P. 2,423,176. Production of Aromatic Hydrocarbons. R. M. Cole to Shell Development Company.

Sulfur-bearing olefinic petroleum fractions are treated with hydrogen at a temperature of 450-850° F. in the presence of a self-active hydrogenation catalyst, such as WS_2, Ni_2S_3, Fe_2S_3, etc., under conditions such that the S-content of the material is reduced while incompletely hydrogenating the olefins. The product obtained is mixed with a saturated isomerized hydroaromatic fraction as obtained in a later stage of the process. A mixture containing less than 0.1% S is thus produced. This mixture is treated with hydrogen at a temperature of 850-1000° F. in the presence of a dehydrogenating sulfide of a metal of the iron group, e.g., Ni_2S_3 or a mixture of Ni_2S_3 and WS_2, under conditions such that further desulfurization, dehydrogenation of naphthenes and a substantial saturation of olefins is effected. Aromatic products are removed. The remainder is fractionated to separate a fraction rich in non-hydroaromatic naphthenes. This fraction is subjected to catalytic isomerization, e.g., by means of a Friedel-Crafts type catalyst, producing hydroaromatic naphthenes. At least a portion of this isomerized material is recycled as the aforementioned hydroaromatic fraction to the second hydrogen treatment. Toluene can, for example, be obtained as the predominant aromatic product.

U.S.P. 2,423,238. Production of Gaseous Hydrocarbon Products Free from Volatile Sulphur Compounds. C. O. Hoover to Air Reduction Company, Inc.

Hydrocarbon gases and vapors are absorbed in an absorbing oil, such as gasoil. An oil-soluble cuprous compound, e.g., cuprous naphthenate, is introduced, whereby the sulfur compounds present in the gases or vapors, viz., free H_2S, mercaptans and disulfides, are converted to non-volatile forms. The absorbed hydrocarbon gases and vapors are then recovered, free from the sulfur compounds, from the absorbing oil by vaporization.

HEAVY OILS AND WAXES

U.S.P. 2,421,968. Method of Conveying Fluids. A. H. Schutte to The Lummus Company.

A high melting point, normally solid crystalline hydrocarbon material (wax) is rendered transportable at a temperature below its m.p. and transported to a distant point through a pipe line by liquefying the material, emulsifying the liquefied material with water and air, cooling the emulsion to a pumping temperature below the m.p. of the material to solidify at least a portion of the material and thereby stabilize the emulsion. After pumping the thus treated emulsion through the pipe line, the water is separated from the hydrocarbon material.

U.S.P. 2,422,075. Stabilized Lubricating Emulsions. M. D. Bray to The Texas Company.

The lubricating emulsion according to this patent comprises an emulsion of mineral oil-in-water and a guanidine salt of a soap-forming saturated fatty acid, such as guanidine stearate, as the emulsifying agent. An alkylolamine salt can also be present in amounts sufficient to stabilize the emulsion at elevated temperatures. For example, stearates of ethanol amines or propanol amines can be employed.

U.S.P. 2,422,206. Method of Preparing Composition of Matter Suitable for Use as a Lubricant and as an Addition Agent to Lubricants. J. M. Musselman to The Standard Oil Company of Ohio.

A phosphorus sulfide is reacted at a temperature of at least 270° F. with an ester type wax in the presence of at least 10% of a mineral oil as a diluent. The yield of the reaction product is improved and the formation of a phosphorus and oxygen containing by-product is minimized by the presence of the diluent. The composition formed is utilized either as a lubricant or as an additive for mineral oils to improve their lubricating properties.

U.S.P. 2,422,243. Lubricating Composition. A. T. Knutson and E. F. Graves to The Lubri-Zol Corporation.

A major proportion of mineral lubricating oil is mixed with a compound of

$$R-\overset{\overset{O}{\|}}{S}-OR'$$

the formula R—S—OR' where R is an aliphatic substituted aromatic radicle and R' is hydrogen, an organic radicle, or basic radicle. p-Ethyl benzene sulphinic acid or its esters are examples of the additive employed. It is used in an amount sufficient to impart extreme pressure properties to the lubricant.

U.S.P. 2,422,247. Lubricants, etc., Containing Waxy Hydrocarbons and a Ketone-Aromatic Condensation Product as Wax Modifier. E. Lieber and A. F. Cashman to Standard Oil Development Company.

The oil composition according to the patent comprises a waxy mineral lubricating oil base and a pour depressing amount of a Friedel-Crafts condensation product of an aliphatic ketone with less than 10 C atoms and a low m. w. aromatic compound of the general formula ArR_n, where Ar is an aromatic nucleus, at least one R is replaceable hydrogen and the other R's are hydrogen, halogen, alkyl, aryl, aralkyl, alkoxy, or hydroxy radicals. The condensation product employed as the additive shall be substantially non-volatile under fire and steam distillation conditions at temperatures up to 600° F. The condensation product can, for example, be obtained by reaction of a dialkyl ketone with less than 5 C atoms with naphthalene. It can also be utilized for modifying wax.

U.S.P. 2,422,275. Compounded Lubricating Oil. C. Winning and D. T. Rogers to Standard Oil Development Co.

The extreme pressure lubricant according to the patent consists essentially of a mineral lubricating oil and contains 0.02-15% of a product obtained by reacting 1-3 mol proportions of an aliphatic or alicyclic compound which contains an unsaturated C-to-C linkage, at a temperature of 20-140° C. with 1 mol proportion of a sulfur halide, and by further reacting ½-10 mol proportions of the product thus formed with 1 mol proportion of an aromatic compound at a temperature of 40-160° C. The additive can, for example, be obtained by reacting 1-3 mol parts of an olefin with 1 mol part of sulfur monochloride, and ½ to 10 mol parts of the product obtained with 1 mol part of phenol.

U.S.P. 2,422,276. Compounded Lubricating Oil. L. A. Mikeska to Standard Oil Development Company.

The product of this patent is similar to that of U. S. patent 2,422,275. In the present case ½ to 10 mol proportions of the reaction product first obtained in accordance to U. S. patent 2,422,275 are reacted with a compound of the formula R-Ar-OT where Ar is an aromatic nucleus, R represents at least one aliphatic side chain consisting essentially of an alkyl group with at least 20 C atoms, and T is hydrogen or a metal equivalent of hydrogen of the groups II, III, IV, or VIII of the periodic table.

U.S.P. 2,422,278. Lubricating Oil Composition. D. W. Young and J. D. Calfee to Standard Oil Development Co.

To improve the viscosity index of a lubricant, a relatively small amount of a reaction product of the polymerized methyl pentadiene (e.g., 2-methyl pentadiene-1,3) with a mol weight of 8000-25,000 and a maleic anhydride compound is dissolved in the hydrocarbon oil.

U.S.P. 2,422,443. Condensation of Hydrocarbons. W. A. Smith.

Petroleum hydrocarbons of relatively small complexity, such as California crude oils, are chemically condensed into hydrocarbons of greater complexity by treating the starting material with HCl gas. The thus treated hydrocarbons are contacted for a substantial interval with acid-activated clay and an oxide of Cu at a temperature above 400° F. but below that which would cause degradation of the hydrocarbons. The chemically condensed product is separated from the clay and copper oxide. Crude oils containing relatively large amounts of light bodied lubricating components can thus be changed to oils which contain heavy bodied components such as are, for example, desirable in the lubrication of aircraft engines.

U.S.P. 2,422,585. Lubricant. T. H. Rogers, R. W. Watson and J. W. Starrett to Standard Oil Company of Indiana.

A major proportion of a lubricating hydrocarbon oil is mixed with 0.01-5 percent by weight of a sulfurized terpene and 0.001-10 percent of the neutralized reaction product of phosphorus sulfide with a hydrocarbon, such as an olefin polymer. The lubricant is non-corrosive and resistant to oxidation.

U.S.P. 2,422,630. Preparation of Lubricants. J. M. Musselman and H. P. Lankelma to The Standard Oil Company of Ohio.

A product suitable for use as a lubricant and as an addition to lubricating oils is obtained by heating an organic thiophosphate reaction product of a phosphorus sulfide and an aliphatic oxygen-containing organic compound to a temperature above 275° F. for a length of time to form a separable sludge containing P, and a desired decomposition product with a P content of less than half that of the thiophosphate starting material and most of the S content thereof. The desired decomposition product is separated from the sludge. The product can be applied as such in lubricating gearings, etc., or it can be compounded with a lubricating oil in amounts of 0.5-5 percent, or more. The

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Wilson EP Series Air Motor with Model F Cutter Head.

Bring on your clogged up tubes with the heavy deposits and sticky scale!

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The secret of these extras in power, speed and economy? It's in the six-bladed, light-bladed construction. With the EP motor you get higher torque at any speed because six blades produce a smoother flow of power . . . 12 powerful impulses per revolution. Light blades eliminate the need for expensive cylinder replacement. Automatic valving of operating air means less air-consumption . . . a minimum of back pressure. Its six blades eliminate "dead" center . . . make it easy to start—hard to stall. Why not see your local Wilson Representative about cost cutting EP Motors today?

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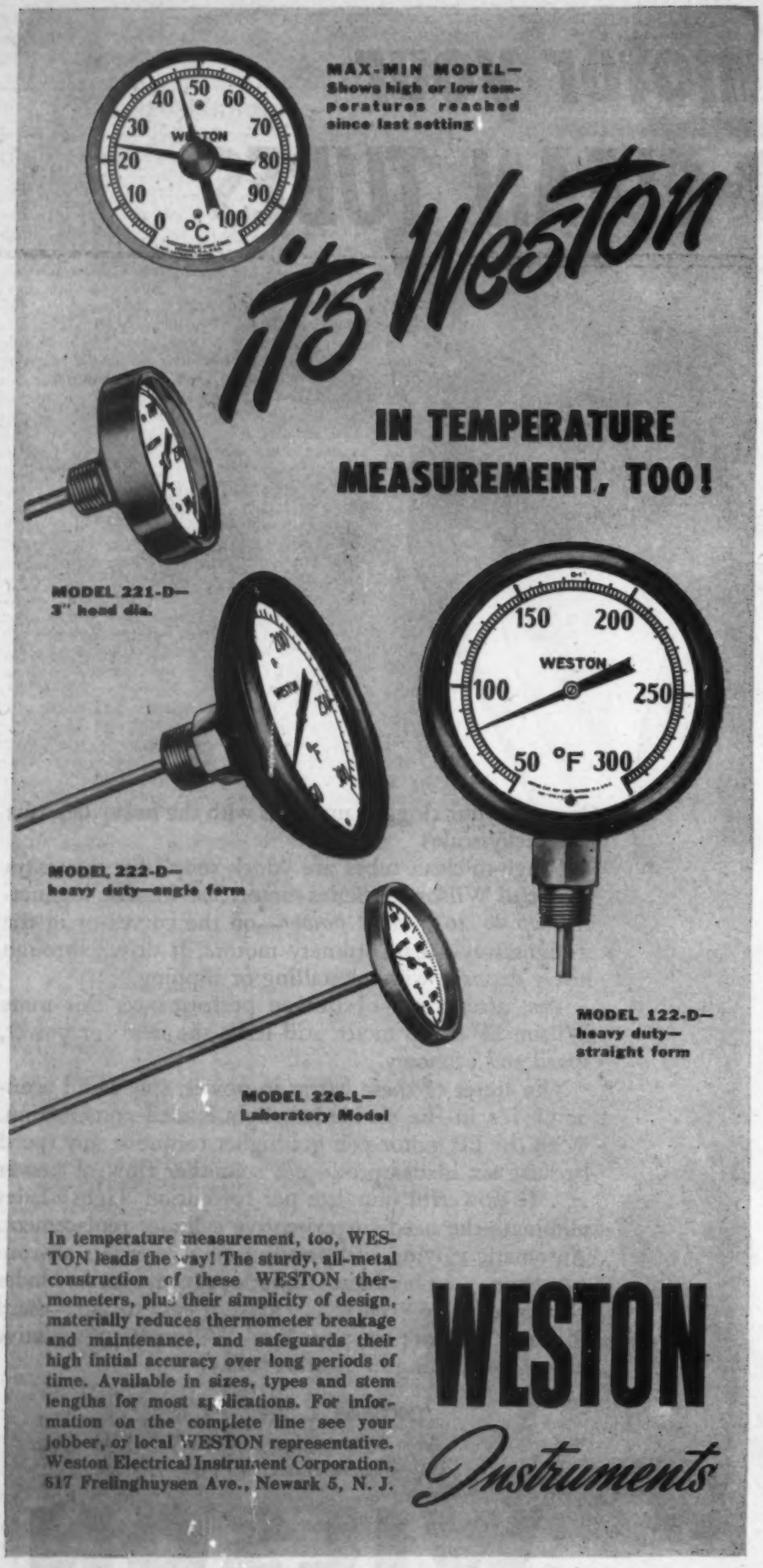
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new lubricant is valuable under extreme pressure conditions and it is non-corrosive and very stable.

U.S.P. 2,422,769. Lubricant. E. S. Blake and K. L. Godfrey to Monsanto Chemical Company.

The lubricant comprises a major proportion of a lubricating oil and a minor proportion of a chlorbenzyl ester of an alkyl xanthic acid, wherein the chlorine is linked to the phenyl nucleus of the benzyl group. Ten percent of trichlorbenzyl ethyl xanthate can, for example, be employed as the additive. Extreme pressure properties are imparted to the oil.

U.S.P. 2,422,881. Lubricating Oils. C. M. Blair, Jr., to Petrolite Corporation, Ltd.

The product referred to in this patent consists of a mineral lubricating oil and a relatively small amount of an aliphatic saturated alcohol-alpha-beta unsaturated dicarboxy acid-unsaturated aliphatic alcohol condensation product. The saturated alcohol contains 8-22 C atoms, the acid not over 5 C atoms, and the unsaturated alcohol at least 3 intervening C atoms between the C atom to which the OH group is attached and the nearest ethylenic C atom. This condensation product results from a reaction in which the molal proportions of the alpha-beta unsaturated dicarboxy acid to the unsaturated alcohol are within the range of 1.5-2.5 and the saturated alcohol reactant is such that the total equivalents of alcoholic reactants is about equal to the equivalents of dicarboxy acid used. An amount of 0.025-5 percent by weight of the additive, on the basis of the lubricating oil, is employed. For example, stearyl alcohol can be used as the saturated alcohol, oleyl alcohol as the unsaturated alcohol, and maleic anhydride, fumaric acid, or citraconic anhydride as the dicarboxy acid component for the additive. The viscosity index of the lubricant is increased by the additive while the pour-point is lowered.

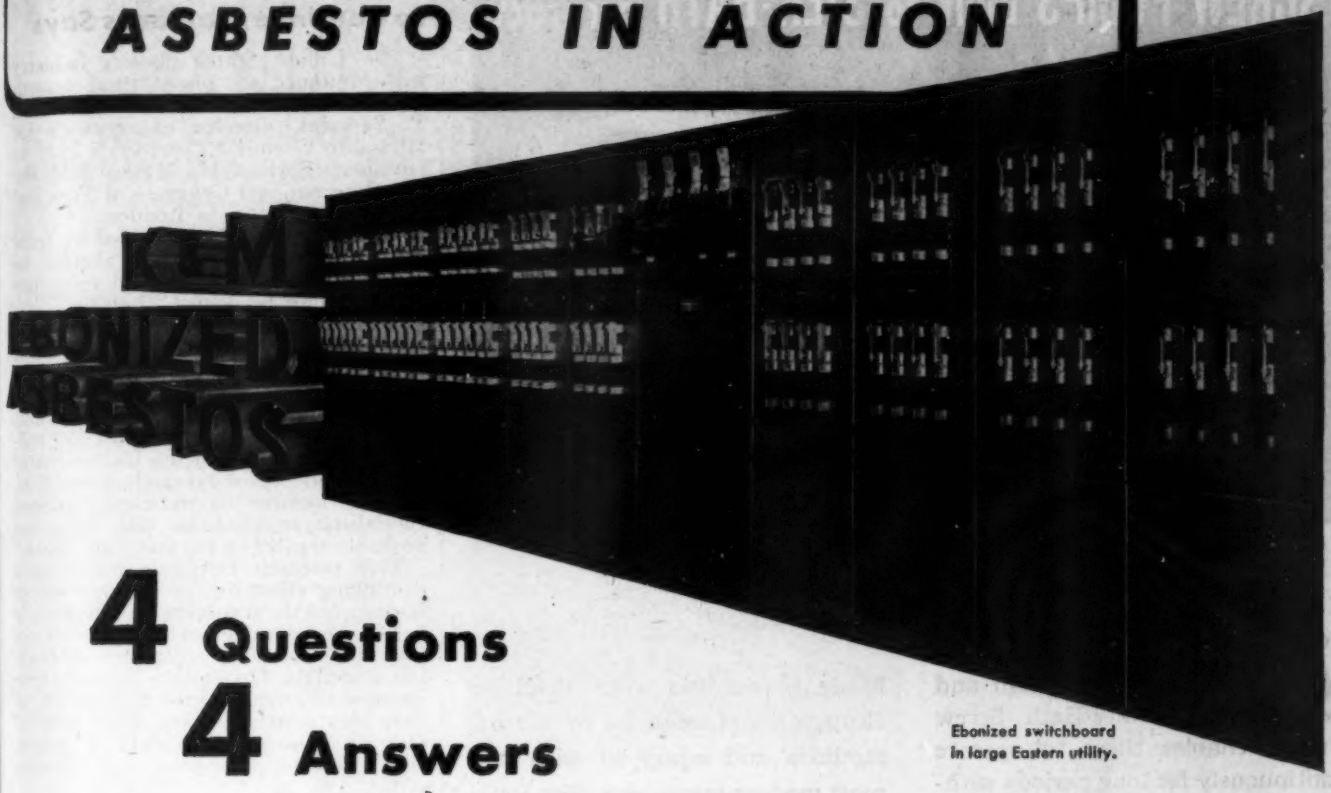
U.S.P. 2,423,144. Emulsifiable Hydrocarbon Oils and Emulsions Thereof. G. W. Gregg to Shell Development Co.

The emulsifiable oil according to this patent comprises a major proportion of a hydrocarbon oil having dissolved therein an organic oil-in-water emulsifier, e.g. a soap type emulsifier, and an alkali metal tetraphosphate in an amount sufficient to stabilize the emulsion to be formed, such as for instance 0.3-5 percent of such compound. The emulsions are particularly effective as grinding and cutting oils.

U.S.P. 2,423,413. Electrical Insulating Oils. F. J. Soday to The United Gas Improvement Company.

The electrical insulating oil according to this patent comprises an aromatic hydrocarbon oil boiling above 210° C., and containing a mixture of aromatic hydrocarbons which constitutes at least 95 percent of the oil. The hydrocarbon mixture has a mixed aniline point below 15° C. It is preferably separated from petroleum tar produced in the vapor phase pyrolysis of petroleum oil. Castor oil can be admixed to the aromatic hydrocarbon oil.

ASBESTOS IN ACTION



Ebonized switchboard in large Eastern utility.

4 Questions 4 Answers

TO HELP YOU SPECIFY YOUR ELECTRICAL MOUNTING MATERIAL

Q: ***What is Ebonized Asbestos?***

A: Ebonized Asbestos is a combination of asbestos fibres, a binder and an insulating compound—an ideal dielectric mounting for switches, controls, meters; for compartment linings, testing tables, cabinets, bus bar runs and supports.

Q: ***What about its dielectric strength?***

A: Ebonized Asbestos has exceptionally high dielectric strength. It can be supplied in thicknesses from ⅛" to 4".

Q: ***How about absorption of moisture and oil?***

A: Because of its composition, Ebonized Asbestos effectively resists the action of moisture and oil.

Q: ***Can it withstand shocks, vibration, rapid temperature changes?***

A: Absolutely. This is because Ebonized Asbestos is molded under tremendous hydraulic pressure into a dense, tough, monolithic sheet that possesses very high mechanical strength. Yet it is readily workable; can be drilled and machined as needed.

It will pay you to keep these points in mind when you lay out your next switchgear or control board jobs. If there are other facts you'd like to know about Ebonized Asbestos, we'll give your inquiries prompt attention.

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SCREW PUMPS built to SIER-BATH accuracy

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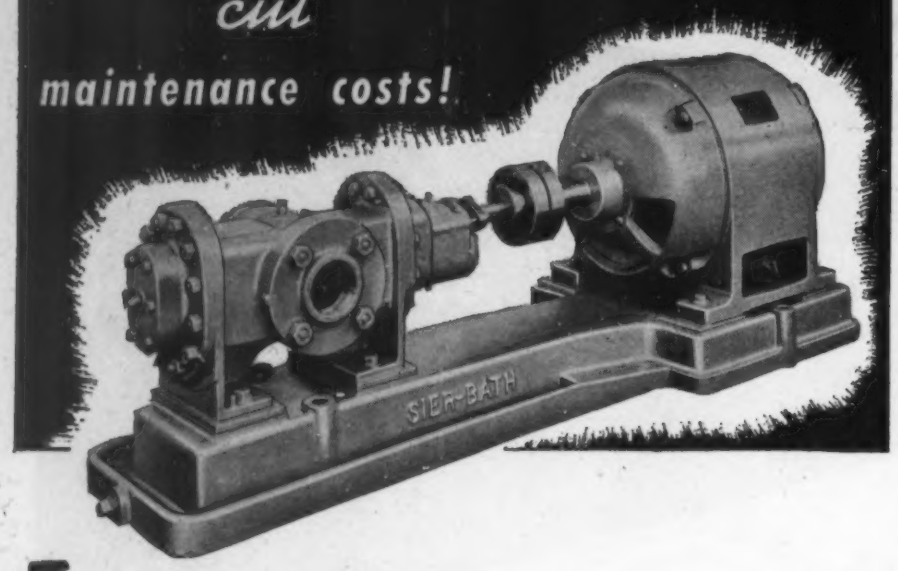

The high quality of design and construction of Sier-Bath Screw Pumps enables them to operate continuously for long periods without maintenance. The pulseless flow and vibrationless operation of these pumps greatly reduce maintenance cost—there is less wear on valves, couplings and other fittings. Pipes and joints remain tight and require little attention. With maintenance labor costs at an all-time high, these are important points to consider today in the selection of pumps.

Made in an up-to-date machine shop, accustomed to precision methods and equipped with the most modern machinery, Sier-Bath Screw Pumps always measure up to the highest standards required by users. They are made in both horizontal and vertical models.

Sier-Bath customers are protected from mis-application by the mature pump engineering experience of this Company's staff. Send for descriptive booklet.

ADVANTAGES:

● pulseless flow ● anti-friction bearings ● vibrationless operation

● low maintenance cost ● rugged construction

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Plastics Industry Growth To Continue, Samaras Says

The United States plastics industry will continued its phenomenal growth for at least another five years Dr. N. N. T. Samaras, director of research for Monsanto Chemical Company's Plastics Division (Springfield, Mass.) told the 11th International Congress of Pure and Applied Chemistry in London.

The growth would be "aided by technological developments and abetted by a youthful aggressiveness and versatility which cannot be denied," he said.

Greatly accelerated research in the plastics field during the past eight years has been of considerable influence in the tremendous growth of the industry during that time, he pointed out, saying: "We can estimate that at least $50 million has been spent in the United States on synthetic resin research since 1939, and the number of technically trained specialists engaged in this field has probably trebled in the last eight years."

This research emphasis will have a continuing effect on the industry whose future growth, according to Samaras, is based on development of blends of plastics, mechanical alteration of existing materials, innovations in mass production techniques, greater supplies of basic raw materials, and pioneering of plastics research in the field of carbon, silicon, sulfur, phosphorus and nitrogen types.

Dr. Samaras said that in 1939 the United States achieved world plastics leadership, producing 250 million pounds of intermediates valued at $50 million. The real growth occurred during the next seven years, however, when production was increased 500 percent, this expansion being exceeded only by that of synthetic rubber and magnesium.

Ability to combine with other materials has been little developed by the industry, the speaker stated.

Certain economic factors which have had great influence on the industry growth, he said, include:

1) Steadily declining prices which have stimulated wider interest and application. 2) The United States has a relatively abundant and varied source of raw materials, and 3) the industry has benefited from sustained confidence in its ability to make money. Indicative of this faith is the fact that the plasics producers in the United Sates intend to spend an estimated $150 million for expansion of production facilities in the 1946-1948 period."

Assistance Needed in Translating Technical Data

The Department of Commerce's Office of Technical Services has asked assistance of technical societies, trade associations, other industry groups and individuals in evaluating 500,000 technical documents which would be published as a compendium of German wartime industrial technology. Much refining data are included.

OTS Director John C. Green said that experts who volunteer their services will benefit by being the first to scrutinize original documents which are in German. Such volunteers also may publish articles based on the documents in technical journals under their own names. Later they would be available for use in the proposed compendium.

NEW EQUIPMENT

. . . MANUFACTURERS' · LITERATURE . . .

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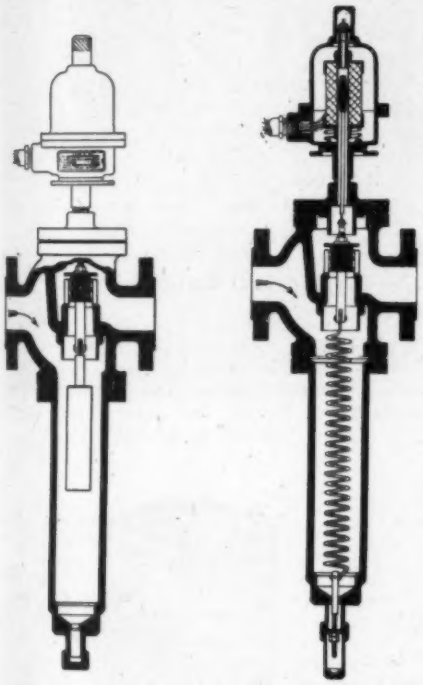
1—Electronic Area Meter

A new electronically-operated area meter has been designed by Bailey Meter Company to measure accurately the more viscous liquids; black liquor, tar chemicals, distillates, and refrigerants as well as freer flowing liquids: water, oil, gasoline, etc. It consists of a specially designed telemetering transmitter connected to a standard Bailey electronic receiver. The transmitter is easily installed in the pipe line, much like a valve.



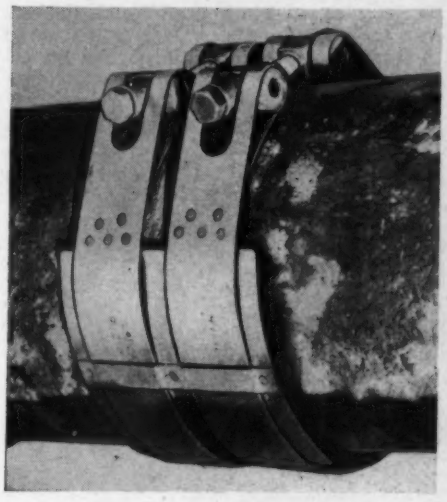
Bailey electronic area meters. Weight loaded transmitter at left and, right, spring loaded transmitter.

This area meter is said to have several advantages over other types of flow meters: its installation is simplified as the recorder is constructed of packaged electronic components which do not need to be carefully leveled and are not affected by vibration; the recorder may be calibrated to read in terms of volumetric units thereby reducing errors due to density changes; two transmitters may be connected to the same recorder to measure the ratio, sum or difference of two flows.

CHECK THE CARD AT PAGE 240

2—Pipe Leak Clamp

Harman Products Company, Inc., 940 West Redondo Boulevard, Inglewood, California is offering a high pressure pipe leak clamp for pressures up to 1100 pounds. It is designed for application to corroded pipes and for permanent repair applications for oil, gas and water piping. They are made of stainless steel in sizes to fit pipe from 2 inches to 8 inches. Larger sizes can be provided upon request.



Harman Pipe Leak Clamp

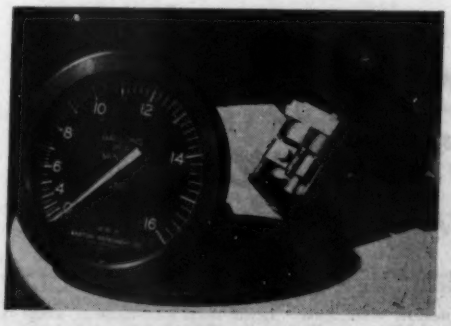
The clamps are provided with a laminated inner surface of synthetic rubber, which compresses into corroded areas as the device is applied. Maximum weight is six pounds so installation can be done by one man.

CHECK THE CARD AT PAGE 240

3—Differential Pressure Indicator

Barton Instrument Company has announced the new Model 181 differential pressure indicator featuring a six-inch dial for easier visibility; wide differential pressure range (0-50 inches of water up to 0-200 psi); universal mounting and an improved vapor-proof case. It is constructed of drawn bar stock and has brass rupture-proof bellows. Static pressure ratings extend up to 3000 psi. Size of the indicator is 7½ inches diameter, depth 4½ inches.

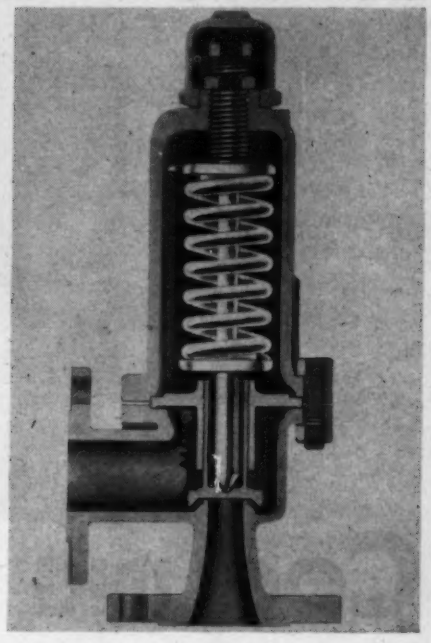
CHECK THE CARD AT PAGE 240



Differential Pressure Indicator

4—Acid-Resistant

Farris Engineering Corporation, Palisades Park, N. J., has developed a line of corrosion resistant safety and relief valves aimed to effect a marked reduction in valve maintenance costs on installations handling corrosive vapors or gases.



Ferris Acid-resistant Valve

"Hastelloy-C" is used for the inserted nozzle and the valve disc and, in certain models, for the complete valve body.

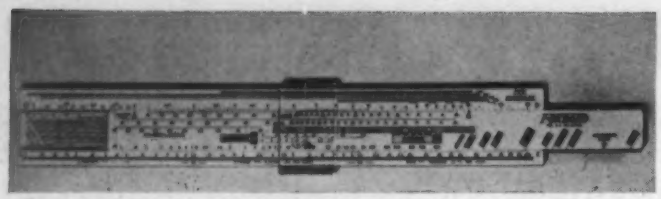
All working parts of the valve are isolated behind a vapor proof "Farri-Seal" curtain. This protective seal is a flexible material attached to the disc at one end and the flanged disc guide at the other, in such a way as to completely isolate the working parts from the gas or vapor within the body of the valve.

Valves are available with flange connections in sizes from ½ to 2-inch; with screwed connections in sizes from ½ to 1-inch.

CHECK THE CARD AT PAGE 240

5—Flow Rule

The new Foxboro Flow Rule is a specially designed 12-inch slide rule for computing orifice plate bores, flow nozzles or Venturi throats, and also the rate of flow, or the differential created across the orifice plate (whether flange tapped or full flow tapped) or other primary device. It can be used for all fluids, with or without seals, and covers such a wide range of flows and line sizes



Foxboro Flow Rule

that it will handle almost any commercial problem. Although its average error is well within the accuracy of flow test data, it is not intended to replace computation methods where purchase and sale of fluids are involved. It will, however, be found to be invaluable for checking such calculations.

The cost of the rule may easily be saved, many times over, where the correct determination of line size or flow rate is important.

The flow rule is made for The Foxboro Company by Cox & Stevens Aircraft Corporation, who developed the scale rules used in operation-calculations for the B-29 bombers. It is constructed on moisture-proof plastic, free from effects of warpage or thermal contraction or expansion.

CHECK THE CARD AT PAGE 240

6—Dry Chemical Extinguisher

A new 4-pound model dry chemical fire extinguisher, known as the Ansul 4, which has received high ratings for effectiveness from national approval agencies, is announced by the Fire Extinguisher Division of Ansul Chemical Company, Marinette, Wis. The extinguisher, 19⅛ inches long and 3½ inches in diameter, is suitable for extinguishing fires in flammable liquids, gases, solids and electrical equipment and also for controlling fires in ordinary combustibles. The extinguishing agent used is claimed to be nontoxic, non-corrosive, non-abrasive and a non-conductor of electricity.

Maintenance is said to be greatly simplified and the extinguisher can be quickly recharged on-the-spot after use.

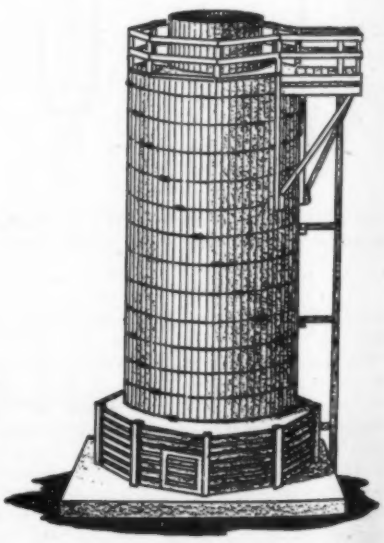
Ansul Extinguisher

CHECK THE CARD AT PAGE 240

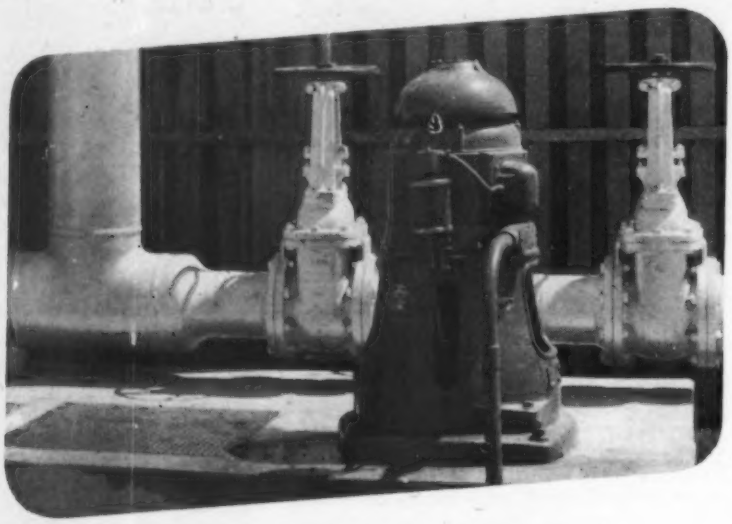
7—Cylindrical Cooling Tower

Patent disclosures by Santa Fe Tank and Tower Company of Los Angeles reveal a new development in cooling tower construction and design, the cylindrical tower, the underlying principle, design and construction of which is entirely new. The cylindrical tower is designed to eliminate dead air spaces which occur in present day rectangular and octagon shaped towers. The new cylindrical tower is the first of its kind, having been conceived by Santa Fe engineers only last November.

Also noteworthy, the design is said



Cylindrical Cooling Tower



COOLING TOWER WATER

—OR WATER FOR ANY PETROLEUM NEED

Not how cheap but how good has always been the policy of the builders of Layne Well Water Systems.

For cooling tower—or use in any part of the petroleum processing or pumping industry, Layne Well Water Systems produce large quantities of water at an extra low cost.

These systems are scientifically engineered to have the rugged quality that assures extra long life and freedom from expensive unkeep cost. If you have a specific water producing problem, Layne engineers will gladly cooperate and offer logical and economical plans. No obligation.

Systems of any size—any capacity against any head. For further interesting details and facts, address Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

LAYNE *Well Water Systems* VERTICAL TURBINE Pumps

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. * Layne-Atlantic Co., Norfolk, Va. * Layne-Central Co., Memphis, Tenn. * Layne-Northern Co., Mishawaka, Ind. * Layne-Louisiana Co., Lake Charles, La. * Louisiana Well Co., Monroe, La. * Layne-New York Co., New York City * Layne-Northwest Co., Milwaukee, Wis. * Layne-Ohio Co., Columbus, Ohio * Layne-Pacific, Inc., Seattle, Washington * Layne-Texas Co., Houston, Texas * Layne-Western Co., Kansas City, Mo. * Layne-Western Co. of Minnesota, Minneapolis, Minn. * International Water Supply Ltd., London, Ontario, Canada * Layne-Hispano Americana, S. A., Mexico, D. F.

to allow air to enter the tower from any point of the entire 360° circumference, instead of from only two sides—or two sides and four corners. This factor accounts for a more even distribution of air, and also reduces the need for baffles or diverters.

The cylindrical tower may be built in either individual or multiple-cell units, either of wood or steel construction.

CHECK THE CARD AT PAGE 240

8—Drum Handling

For safe handling of drums which must be moved singly or in the upright position to prevent spilling, Clark Tructractor, Division of Clark Equipment Company, Battle Creek, Mich., has recently perfected a new clamping device

Clark Drum Handler

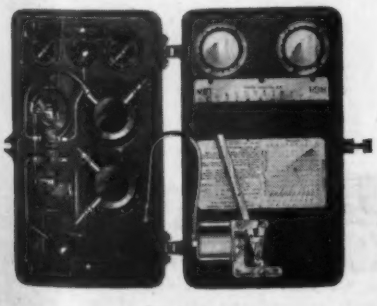
which is easily adapted to any of their fork truck models.

The clamp is self-adjusting for diameters 21½ to 24-inch and employs a star cam permitting the operator to release the drum without dismounting. The device grips securely throughout transportation and carries up to 700 pounds. This new clamp may also be used on fork trucks equipped with crane, swinging boom, or special fork extension attachments.

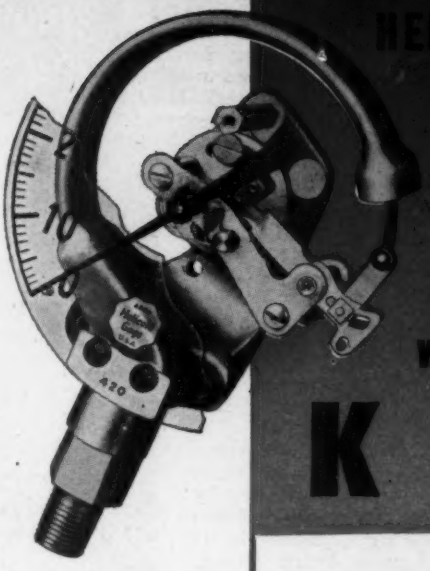
CHECK THE CARD AT PAGE 240

9—Dual Pilot Control

Fisher Governor Company, Marshalltown, is offering the Fisher "Dual-Pilot Level-Trol," Series 2406-248, of the displacement type for indicating or record-



Dual Pilot Level-Trol



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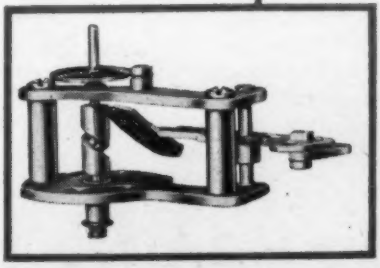
with Bourdon Tube of

K MONEL

With superior spring characteristics and high resistance to corrosion, K Monel is unequalled for certain difficult pressure gage applications. In actual service under the worst corrosive conditions, such as Hydrogen Sulphide gas or oil, Helicoid Pressure Gages with K Monel Bourdon Tubes have remained accurate ten times longer than gages with stainless steel tubes.

K Monel Bourdon tubes are made of Korex tubing, with extra-smooth inside wall, for all pressures from 30 p.s.i. to 10,000 p.s.i.

- **These tubes are fused** to forged Monel sockets and tips—no solder, no welding rod—providing an integral Monel system. Heat-treated to obtain maximum spring properties in tube.
- **K Monel Gages cost no more** than stainless steel tube gages. Yet they are infinitely superior for prolonged accuracy and low hysteresis effect.
- **Try Helicoid Gages now** with K Monel tubes. Send for your copy of the new Helicoid Gage catalog.



The Helicoid Movement is one of many exclusive features of the Helicoid Pressure Gage.

ACCO

HELICOID GAGE DIVISION

AMERICAN CHAIN & CABLE

Bridgeport 2, Connecticut

TRADE MARK

ing and controlling of liquid levels. They are built with separate pilot units for each function of operation. The unit can be installed and the indicator portion set to indicate or record level over the full float range and then locked in position. The control function is handled by the second pilot, which pilot may be adjusted by the operator without danger of disturbing indication or recording of level within the vessel upon which the unit is located.

CHECK THE CARD AT PAGE 240

10—D-C Arc Welder

General Electric Company, Schenectady, N. Y., has designed a new line of heavy-duty, single-operator d-c arc welding machines, Type WD-40 series, designed for improved welding characteristics and a 50 percent saving in overall size and weight. Operating at 3500 rpm, the new welders are available in 200-, 300-, and 400-ampere NEMA ratings.

The arc is easily established and

G. E. Arc Welder

maintained with the new welders because more than full arc voltage is generated instantly after short circuit, thereby largely eliminating arc pop-out. Excessive weld spatter is reduced because current peaks are adjusted for best performance on any setting.

New single-dial, dual control combines flexibility and precision of dual control, both broad and precise, with the convenience of single-dial control. This feature makes it possible for the operator to preset the correct current for any given job without having to make other adjustments after the arc is struck.

To facilitate inspection and maintenance, weather-resistant end covers on both the welder and the control box can be easily removed with a screwdriver, making the motor, generator, commutator, brushes, and controls readily accessible.

CHECK THE CARD AT PAGE 240

11—Improved Electrode

Air Reduction Sales Company has announced an improved Airco No. 312 electrode which was originally placed on the market two years ago.

According to the manufacturer, the improved electrode has two advantages over its predecessor:

1) It can now be used on AC and DC reverse polarity current. Operating characteristics are said to be equally good on either AC or DC reverse. The former 312 electrode could be used only on DC reverse; and

2) Preheating of the electrode is no longer required with the improved Airco 312 to obtain porosity-free weld deposits. These deposits can be obtained by using either the stringer bead or the full weave technique.

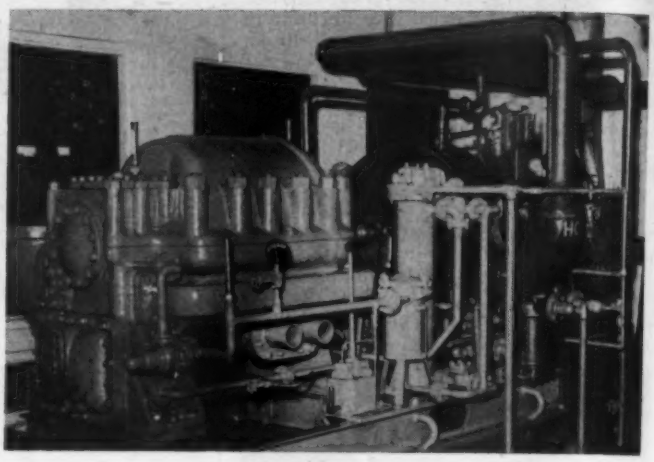
CHECK THE CARD AT PAGE 240

12—Propane Centrifugal

A successful run-in test of the first centrifugal compressor ever to use propane in a refrigeration cycle—opening a new field of possibilities in the process industries — has been completed by Carrier Corporation. Set up as a self-contained, complete package, including compressor and turbine as well as auxiliary oil pumps and oil coolers, the new centrifugal covers a floor area only five feet wide by 15 feet long.

This first propane centrifugal will be installed by The Atlantic Refining Company in its new Point Breeze plant. Atlantic will use the machine in its dewaxing process, in which oil is chilled to approximately 25 degrees below zero in order to congeal and remove the wax base.

The unit, model 18T300, will have five stages. It is nominally a 2000 CFM compressor and operates between the levels of 21 PSIA inlet pressure and minus 22 degrees, and discharges into a condenser at 195 PSIA. The compressor runs at a speed of approximately 9400 RPM and requires 975 BHP. It will be direct connected to a 1085 HP steam turbine and will operate on 600 pound and 700 degree steam with 15 pound exhaust.



Carrier Compressor Uses Propane

Other Carrier gas compressors in this same line range in capacity from 1000 to 30,000 CFM.

CHECK THE CARD AT PAGE 240

13—Acid Pump

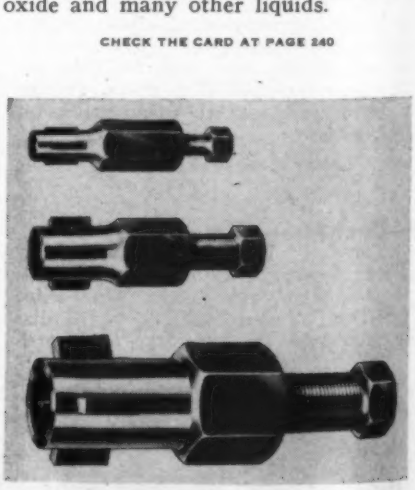
A safe method of acid handling is provided by a manually-operated acid pump, supplied by General Scientific Equipment Company, Philadelphia.

Pump for Acid Handling

Corrosive and other liquids flow smoothly and stop instantly, they come in contact only with the corrosion-resistant tube and cannot affect other parts. When the pump is removed, acid drains completely.

Pumps are supplied in hand- or foot-operated models. Either can be equipped with a lead tube for sulphuric, hydrochloric, hydrofluoric and similar acids or with a Saran (flexible plastic) tube for nitric, phosphoric, acetic acids, peroxide and many other liquids.

CHECK THE CARD AT PAGE 240



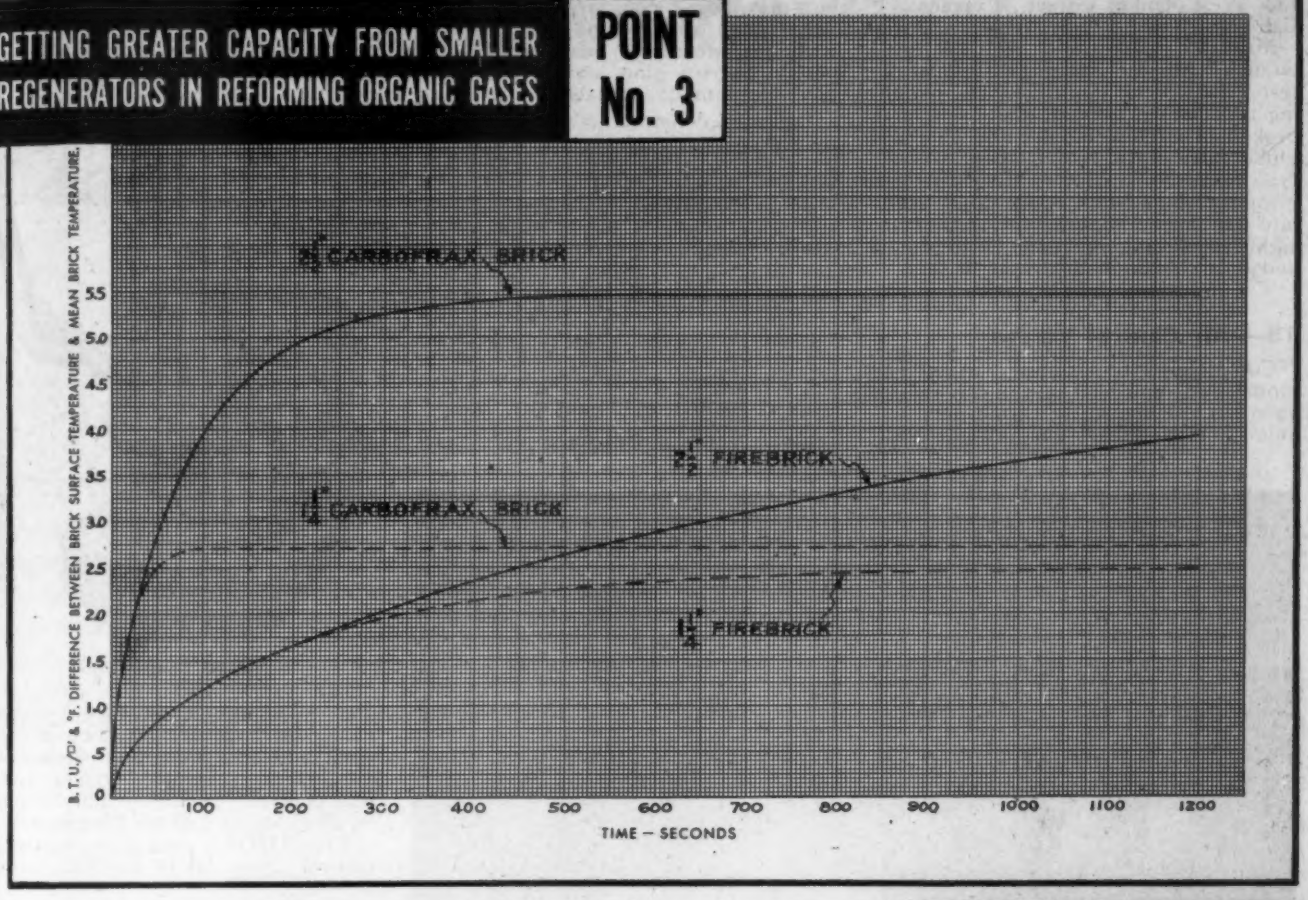
Internal Pipe Wrench

14—Internal Pipe Wrench

A revolutionary new type of internal pipe wrench that is claimed to have sufficient strength to strip a thread without losing its grip is offered by Porst Sales,

GETTING GREATER CAPACITY FROM SMALLER REGENERATORS IN REFORMING ORGANIC GASES

POINT No. 3



CARBOFRAX Checkers provide Faster Heat Release

On reversals, CARBOFRAX silicon carbide brick give up heat equally as fast as they absorb it.

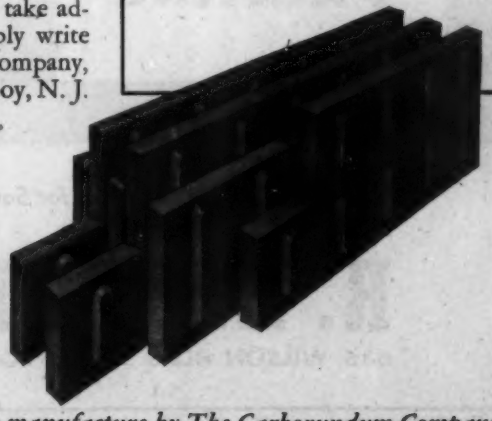
In 35 seconds, 1¼" split CARBOFRAX brick release as much heat as fireclay splits under the same conditions in 600 seconds. This exceptional difference is confirmed by additional data charted. Unlike ordinary refractories, CARBOFRAX brick offer little resistance to heat flow. The explanation is found in their high thermal conductivity—roughly 12 times that of fireclay.

Rapidly heated, organic gases at high velocities can be reformed at rates heretofore considered impractical. Two to four minute cycles for gases at velocities over 400 miles per hour are now used. Greater output from smaller regenerators is the obvious result.

Regenerator design requires special attention to secure maximum efficiency from CARBOFRAX checkers. We suggest that you call in our engineers. They welcome an opportunity to cooperate. To take advantage of their experience, simply write Dept. F-97, The Carborundum Company, Refractories Division, Perth Amboy, N. J.

5 ADVANTAGES
Offered by CARBOFRAX Checkers

1. Faster Heat Absorption
2. Faster Saturation
3. Faster Heat Release
4. High Refractoriness
5. Greater Spalling Resistance



SUPER REFRACTORIES

BY **CARBORUNDUM**

TRADE MARK

"Carborundum" and "Carbofrax" are registered trademarks which indicate manufacture by The Carborundum Company

132 West Union Street, Pasadena 1, Calif.

Marketed as the "B & D internal wrench," this tool has been successfully tested for several months by the plumbing trade in quickly and easily removing broken pipe, close nipples and gate and globe valve seats. It consists of a screw type mandrel that forces outward three gripping dogs until they bite firmly into the inside of the pipe. There are eight sizes ranging from ½ to 6-inch and it is sold individually or in sets.

CHECK THE CARD AT PAGE 240

15—Air Control Valves

Completely re-designed, standard models, an improved line of air control valves is announced by Logansport Machine Company, Inc. The advanced sliding piston-type construction eliminates valve seats and rod packing, together with the wear and maintenance they entail. Seventy-nine standard models have been made available.

Balanced construction produces equal pressure on both sides of the piston, thus assuring effortless operation, the manufacturer declares. Pistons are light in weight, permitting high-speed operation and rapid reversals. Rapid response also results from the full pipe size of ports and internal air passages. Valve seats and rod packing are eliminated and self-cleaning construction gives long life. Durable synthetic rubber cup packings afford positive action without leakage, the 48-page catalogue states. The company is located in Logansport, Ind.

CHECK THE CARD AT PAGE 240

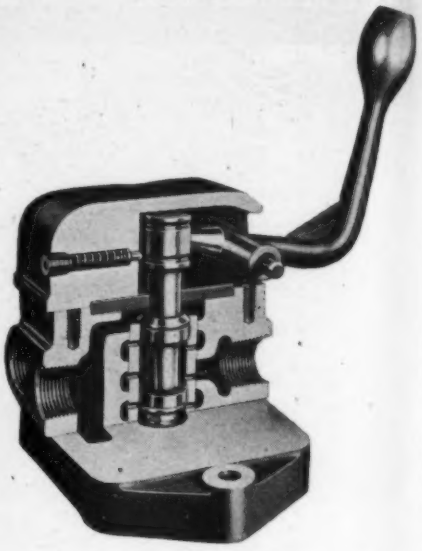
Structural Painters for Southern Industry

R. A. STOKES, INC.

635 WILSON BLDG. CORPUS CHRISTI, TEXAS

16—Flame Failure Safeguard

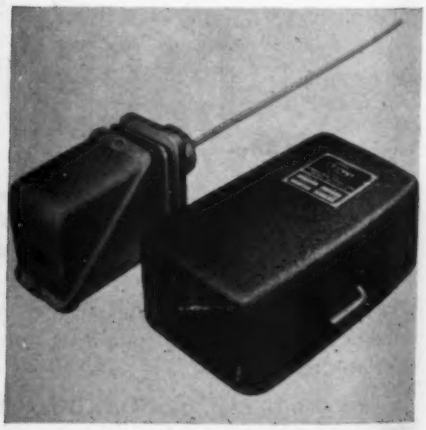
Combustion Control Corporation has announced for industrial gas oven, kiln,



Logan Control Valve

and boiler protection Fireye electronic flame rod Type 45JQ1 which offers "the most advanced electronic design incorporated in several complete combustion control systems—readily applicable to all types of gas-fired burners."

Type 45JQ1 is used with programming control Type 24PJ8 for full automatic



Gas Flame Failure Detector

burners and with control Type 24QJ5 when only operating protection is required.

Fireye is a foolproof electronic flame failure safeguard which actually "feels" the gas flame. When flame fails, it instantly cuts off fuel and can be wired to sound an alarm automatically. Unlike thermal controls, Fireye responds to the flame itself, not to a secondary effect of the flame.

CHECK THE CARD AT PAGE 240

17—Thermometers and Gauges

A new line of recording thermometers and recording gauges known as the Series 500 line of recorders has been announced by Bristol Company, Waterbury 91, Conn. These instruments are housed in a newly-developed modern case and incorporate many design improvements to make them easier to use,

Are your corrosive fluid-line valves *assets* or *liabilities?*

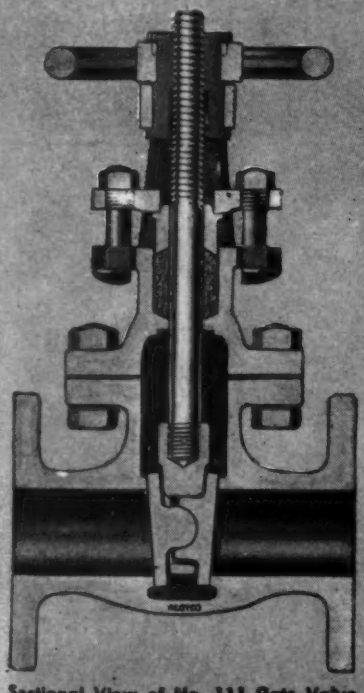
IN corrosive fluid service, a valve is an asset or a liability, depending upon whether or not it always operates positively and lasts for a long period without costly maintenance.

As the Chief Engineer in a large process plant told us recently: "The batches in those kettles are worth as much as $5,000 each. If a valve should stick at the wrong moment, we might lose several thousand dollars. That is why we have to have valves that always operate positively and valves that last. We have never known an Aloyco Valve to stick and they seem to last forever. That is why all new pipe lines and all valve replacements in old pipe lines are Aloyco in this plant, and will be as long as I am chief engineer."

Aloyco manufactures only corrosion resistant valves and fittings. If you want the best valve in the right alloy for your particular application, consult us.

No. 111 GATE

The leader of corrosion resistant valves.



Sectional View of No. 111 Gate Valve showing double-disc, ball-and-socket wedge.

ALOYCO

STAINLESS STEEL VALVES AND FITTINGS

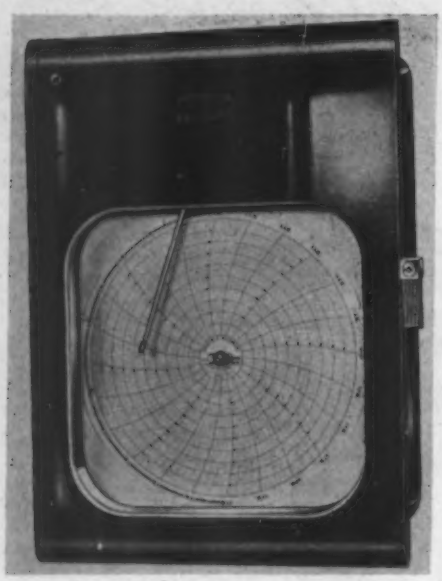
GATE, GLOBE, Y, CHECK, PLUG, FLANGED AND SCREWED UNIONS
SCREWED, FLANGED AND WELDED FITTINGS

ALLOY STEEL PRODUCTS COMPANY, INC.

1303 WEST BELLEFONTE AVE.

more convenient to service, and readily convertible from one type to another. In addition, the company has, wherever possible, simplified the construction of the instrument.

The case is designed so it can be mounted either on a wall, front of panel,



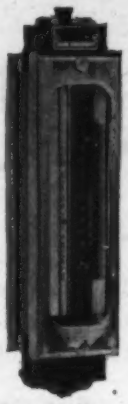
Bristol Series 500 Recorder

or flush on a panel and can be easily converted by the user at any time from one type of mounting to another. Other case features include a heavy inlaid sponge rubber door gasket, flush roll-type door handle, and non-projecting door hinges.

CHECK THE CARD AT PAGE 240

18—Flexible Rotameter Kit

The Brooks Rotameter Company, Lansdale, Pa., has announced a flexible rotameter kit for measuring low flow rates in laboratory and pilot plant research. It consists of one fully shielded rotameter case, four metering tubes that are readily interchanged in the case, and 16 spherical floats, 4 each in pyrex, aluminum, stainless steel and monel. With this combination, 16 liquid flow ranges are obtained, starting at 0.2 cc per minute and reaching a maximum of 200 cc per minute of liquid flow. 16 ranges in gases also are obtained, commencing at 10 cc per minute under standard conditions and extending to 7000 cc per minute. With the addition of two larger tubes and four floats, the top range can be extended to 0.20 gallons per minute of liquid and 0.60 cubic feet per minute of gas.



Rotameter

CHECK THE CARD AT PAGE 240

19—Instrument Air Dryer

Dehydraire Corporation, College Point, N. Y., has developed a new line of instrument air dryers with a capacity of 12½ to 250 SCFM at 100 pounds and 70° which, it is claimed, will dry the air for 25 to 500 air operated instrument installations or for other compressed air uses where absolutely dry air is needed. The air leaving the Dehydraire will have a final dewpoint as low as —50° F, assuring absolute dryness.

These air dryers are being built in

Dehydraire

standard units for either single or polyphase reactivation or steam reactivation where steam pressures of 100 pounds or more are available.

CHECK THE CARD AT PAGE 240

20—Aluminum Trestle Ladder

Aluminum Ladder Company, Worthington, Pa., has developed a new aluminum trestel ladder designed for use with others of its class to support stages and platforms, or it may be disassembled to form two separate units. The adjustable center-piece ladder may be entirely

NH

FORGED STEEL STOP AND GATE VALVES

These Valves having union bonnet, are supplied both inside Screw spindle also external type with yoke (as illustration). Carbon Steel, Nickel Alloy, Monel Metal or Stainless Steel working parts are available according to the services for which they are intended. They have malleable iron "Coolgrip" handwheels and information discs indicating working pressures, etc.

Literature describing these and other Valves and Fittings of interest to the Oil Industry available on request.

ONE OF THE WIDE RANGE OF OUR SPECIALISED PRODUCTIONS FOR THE OIL INDUSTRY

Valves

Specify them for... HIGH PRESSURE & TEMPERATURE SERVICES

Newman, Hender & Co. Ltd

WOODCHESTER NH GLOS ENGLAND

Aluminum Ladder

removed for use as a straight single wall ladder, while the remaining part becomes an "A" type ladder capable of supporting a substantial weight.

CHECK THE CARD AT PAGE 240

21—Diaphragm Type Valves

The diaphragm type valve known as the Hills-McCanna Saunders Patent valve is available from The Duriron Company, Inc., in the corrosion resisting alloys, "Duriron" and "Durichlor." The Duriron valve is particularly resistant to sulfuric, nitric and acetic acids, being practically unaffected in any

FILTER UNITS
by MULTI-METAL

THE superior construction and improved materials of Multi-Metal Filter Units give longer, more trouble-free service resulting in increased production. In addition, because of their advanced design, Multi-Metal Filter Units often can greatly improve the efficiency of existing processing installations.

The skill and experience gleaned from 35 years of intensive specialization are at your service when you place your process problems in the hands of Multi-Metal experts.

Send for free catalog and wire cloth samples, or send prints and specifications for an immediate quotation.

Always in stock—wire and filter cloth of all meshes, weaves, and metals. Order by the yard or piece.

Wire Cloth in Fabricated Units or by the roll and the cut piece

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.

DEAN BROTHERS PUMPS INC. INDEANAPOLIS, INDEANA. PUMPING MACHINERY

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.
INDIANAPOLIS IND.
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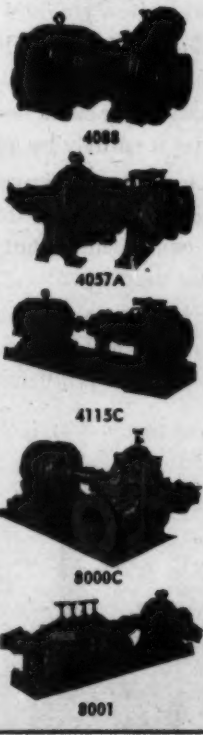
PUMPS
BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL



RECIPROCATING

BRANCH OFFICES
NEW YORK HOUSTON

"Fire protection here calls for instant detection—and prompt extinguishing"

Fire in a plant powerhouse *could* result in a lengthy shutdown —and the need of costly power purchases from outside sources.

Let a Kidde representative show you how this can be avoided!

When *Kidde* Systems, Wheeled Units and Portables protect your electrical equipment, fires are quickly and safely extinguished. *Kidde* equipment discharges *only* clean, non-conducting carbon dioxide—and discharges it entirely by its own stored energy.

No danger of short circuits or flashovers. No corrosion of metal parts . . . no risk of damage to insulation. No danger of the extinguishing equipment failing because pumps or other power sources are shut down!

There may be *other* fire hazards in your plant where the advice of a Kidde representative would be helpful. He's always ready to discuss your fire protection problems with you.

Walter Kidde & Company, Inc., 948 Main Street, Belleville 9, N. J.

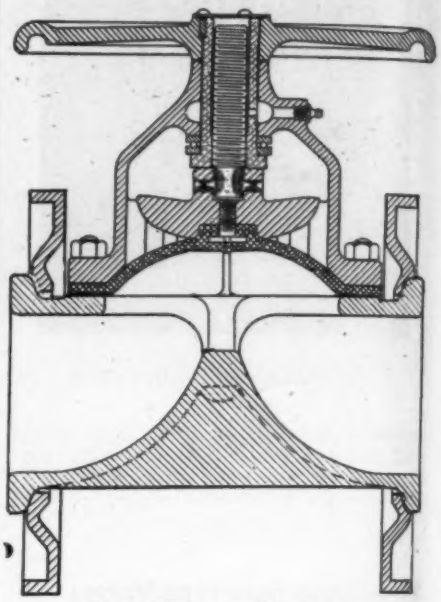
The word "Kidde" and the Kidde seal are trade-marks of Walter Kidde & Company, Inc.

Kidde

FIRE PROTECTION HEADQUARTERS

concentration and at any temperature. Durichlor is recommended for all concentrations of hydrochloric acid at temperatures below the boiling point.

The basic three unit construction—



Durco Diaphragm Type Valve

bonnet assembly, diaphragm and body —is the same in Durco valves as in all other Hills-McCanna Saunders Patent valves.

CHECK THE CARD AT PAGE 240

22—Water Softener

Liquid Conditioning Corporation has developed a new design of hot lime-soda softener in five types which cover a wide range of plant conditions and requirements, and is claimed to obtain the possible benefits of this process to the greatest degree.

The equipment, known as the Liquid hot lime-soda softener, has a deep sludge bed or blanket through which the raw water percolates upwardly. This sludge bed is said to perform several functions, including promotion of thorough contact of the water with the lime and soda ash which it contains, provision of greater completeness of chemical reactions, and the consumption of less chemical than conventional settling tanks.

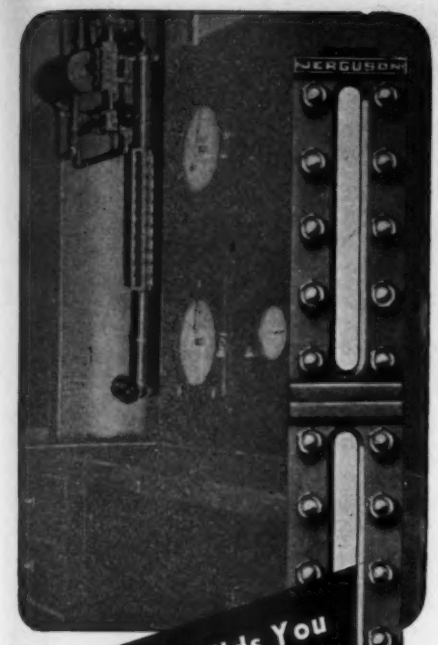
The five types of softeners available provide a selection for different make-up requirements up to 100 percent and for deaeration of make-up or of both make-up and condensate either separately or together.

CHECK THE CARD AT PAGE 240

23—New Valve Line

Wedgeplug Valve Company, Inc., 1300 South Broad Avenue, New Orleans 15, have announced a new "NV" model valve, available in the 8" through 16" Series 60 (ASA 600#, W.O.G. 1500# rating).

This new valve line has a venturi type throat with round port opening. There should be numerous applications for this valve in installations where restricted port openings are acceptable as the prices are considerably less than



Jerguson Builds You THE KIND OF GAGES YOU WANT

You can get the kind of gages YOU WANT when you take your gage problems to Jerguson.

If you want a special gage or valve, or an adaptation of some standard one for a particular need, we'll give it to you. Our technically trained engineers have the ability, the know-how and the WILLINGNESS to pitch in and help you solve your problems.

Jerguson Transparent Gage

Standard gages and valves, of course, are available at Jerguson's in the most complete and varied line offered anywhere.

Corrosion troubles can be eliminated with Jerguson Valves of special materials to withstand liquid action.

Write us about your problems or requirements.

JERGUSON GAGE & VALVE COMPANY

100 Fellsway, Somerville 45, Mass.

Representatives in Major Cities
Phone Listed Under JERGUSON

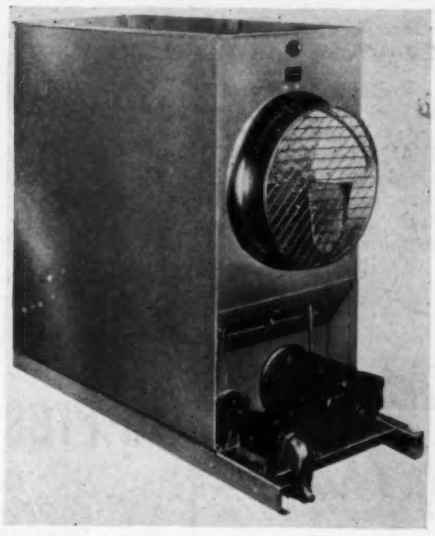
similar valves with full port opening areas. The area of the venturi openings range from 58 to 83 percent the full port areas, depending on the particular valve size considered.

CHECK THE CARD AT PAGE 240

24—Cooling Tower

The Marley Company, Inc., Kansas City 15, Kans., is offering the new Aquatower to the air conditioning and refrigeration field as an answer to the demand for a compact cooling tower of modern design with a high performance rating. Completely assembled at the factory, the Aquatower is sent out as a "packaged product" ready for operation. It is designed with standard components with no special pumps or motors and is engineered for indoor or outdoor service. A heavy steel, integral welded case is used and the tower is sized from 3 to 15 tons of refrigeration.

CHECK THE CARD AT PAGE 240



Aquatower Cooling Tower

25—Measurement and Detection

The Reflectogage—a new instrument utilizing supersonics for thickness measurement and flaw detection—will supplement the Supersonic Reflectoscope and the Thruray already manufactured by Sperry Products, Inc. With the new

Sperry Reflectograph

Faster Cleaning of Aluminum Centrifuges

WHEN clogged centrifuges require disassembly and thorough cleaning, look to specialized Oakite detergents for quick, economical removal of oil, grime and other impurities.

Disassembled parts of aluminum units receive careful treatment when immersed in a recommended solution of a safe-on-aluminum Oakite detergent. Your local Oakite Technical Service Representative will specify solution temperature, time of immersion, solution concentration. Arrange for his FREE in-plant service TODAY! He'll show you how Oakite cleaning cuts scrubbing and scraping to a minimum . . . returns centrifuges to production in less time.

Cleaning Digest Free!

Informative Oakite Petroleum Digest describes the above and 87 other important maintenance cleaning procedures. Write for your FREE copy now! There is no obligation.

OAKITE PRODUCTS, INC.
508 Thames Street, NEW YORK 6, N. Y.
Technical Representatives in Principal Cities of U. S. & Canada

OAKITE

Specialized Industrial Cleaning
MATERIALS • METHODS • SERVICE

instrument thickness of metals and other materials can be measured where access from only one side is available. Maximum error in measurement is less than 2 percent of the thickness of the material.

Thickness of tubing and flat parts, between .005 and .300 inches, can be read directly from the face of the oscilloscope screen. Indirect reading of the thickness of parts up to 4 inches can be accomplished with slight calculation.

The Reflectogage is likewise readily adaptable for the production line testing of thin pieces, or bonded or clad materials, for internal defects or separations.

CHECK THE CARD AT PAGE 240

26—Protective Coating and Lining

A brochure on protective coating and lining for steel and other metals, has been issued by Lithgow Corporation, Chicago. Described are a wide range of Lithcote applications, plant and field facilities, research and actual names of users. Report of actual laboratory tests also are shown.

CHECK THE CARD AT PAGE 240

27—Stationary Diesels

The Superior Engine Division of The National Supply Company has issued a bulletin, No. 4705, describing all models of the company's stationary diesel engines. The bulletin describes how Superior stationary diesels are designed and built. Photographs, performance charts, standard and special equipment tables and dimensional blueprints including foundation sizes and amount of concrete required, are featured as are horsepower ratings and specifications for all engines, both supercharged and nosupercharged.

CHECK THE CARD AT PAGE 240

28—Welding Nickel Alloys

A booklet on the materials required for the metal-arc, oxy-acetylene and submerged melt welding of nickel and the high nickel alloys is being distributed by The International Nickel Company. General information such as the type of welding rods to use, recommended amperages for electric-arc welding, and the proper flux to select for gas welding and brazing also is included as is a list of technical booklets on welding of the high nickel alloy and sources of supply for electrodes and gas welding wire.

CHECK THE CARD AT PAGE 240

29—Tube and Tile Wall

Reintjes tube and tile wall, designed to inclose any contour of tubes and for outer insulation are described in folder B-547, issued by George P. Reintjes Company, Kansas City, Mo. Isometric view of component parts, cross sections, and "a simpler solution for refractory problems" are included in the folder.

CHECK THE CARD AT PAGE 240

30—Resistance Standards, Bridges

Rubicon Company, Philadelphia, announce publication of technical bulletin No. 100 describing their complete line of resistance standards and resistance bridges. Operation, application, construction, and other pertinent data are furnished on Wheatstone, Kelvin, Mueller and Limit bridges. Standard resistors of the Bureau of Standards and Reichsanstalt types, standard shunts and a wide range of Decade resistance boxes are described.

CHECK THE CARD AT PAGE 240

31—Thermometers and Gauges

The Bristol Company, Waterbury, Conn., has published a 16-page Bulletin, No. T835, on its recently announced line of Series 500 recording thermometers and gauges. The bulletin gives detailed descriptions and pictures of the new instruments as well as complete information covering chart ranges, chart drives, thermometer bulbs, and measuring elements.

CHECK THE CARD AT PAGE 240

32—Glass Specialties

Fischer & Porter Company, Hatboro, Pa., has released a new catalog section No. 95-D describing the company's line of precision bore glass specialties. In-

Scores of practical ideas in every issue

Now is the time to start these ideas coming to you. Send in this coupon TODAY

I want to receive PETROLEUM REFINER

here's my check for

☐ 3 years for $4.00
☐ 2 years for $3.00
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City and State_____ Zone_____

Company_____

Engaged in ☐ **Refining** ☐ **Natural Gasoline Mfg.**

Position_____

Equipment . . . or . . . Other Classification—

PLEASE IDENTIFY

Manufacturer

Supply Company ☐_____

Return to P.O. Box 2608 • Houston 1, Texas

Hi-Pressure Gage Glasses

Round, Tubular and Flat Type

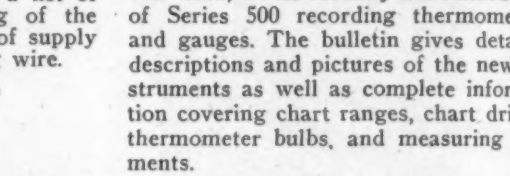


Fig. 12

RUBBER GAGE GLASS GASKETS
Series 750 . . . All Sizes

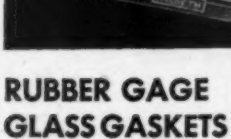


Fig. 21 Fig. 22

Other Ernst Specialties are given in Catalog No. 48-P

GAGE GLASS ILLUMINATORS
NEW PLASTIC GUARDS
SIGHT FLOW INDICATORS
SPLIT-GLAND WATER GAGE
STEEL GAGE VALVES
FLAT GLASS INSERTS
ALL IRON GAGES
HIGH & LOW ALARM COLUMNS
MICA SHIELDS AND GASKETS
AND OTHER HELPFUL TIPS ON BOILER ROOM SAFETY

Inclined for Better Visibility
Standard Type—Offset Adjustable Inclined Gage Fittings

Fig. 4-F

Fig. 13
Leakless Super Try Cocks, Bronze and Forged Steel Construction

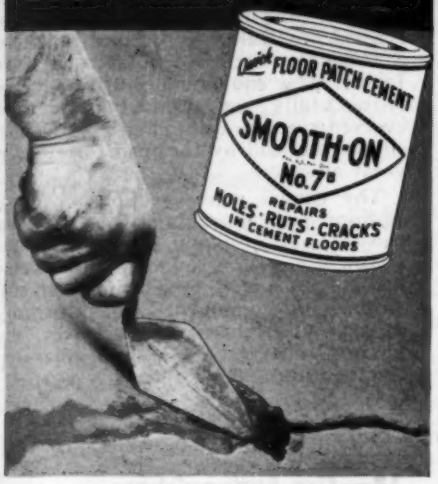
Send for Catalog 48P

Ernst WATER COLUMN & GAGE CO.
LIVINGSTON, N. J. · LIVINGSTON 6-1400

CRACKS RUTS-HOLES

ask for accidents

STOP THEM THIS WAY



Get rid of danger-inviting cracks in concrete floors with Smooth-On No. 7B Quick Floor Patch Cement. Use it to close up ruts, widened seams, shallow holes and rough spots.

Smooth-On patches harden overnight, ready for traffic. They stay so, for Smooth-On expands a little as its sets, wedging itself firmly in place. Furthermore, Smooth-On No. 7B patches get stronger with age, withstand water, are dust-proof and oil-proof.

Order Smooth-On No. 7B Quick Floor Patch Cement in 5-, 25- or 100-lb. size.

FREE **FLOOR PATCH FOLDER AND METAL REPAIR HANDBOOK**

Folder gives full information on patching concrete floors. The 40-page Smooth-On Handbook is full of handy, money-saving repairs on equipment, pipe lines, hardware, tools, utensils, etc. in plant and home. Write for YOUR free copies now.

Sign and Send TODAY

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570 Communipaw Ave., Jersey City 4, N. J.
Please send me QUICK PATCH FOLDER ☐
HANDBOOK ☐

Name_____

Address_____

9/47_____

Do it with **SMOOTH-ON**
QUICK FLOOR PATCH CEMENT

cluded is a list of more than 100 standard stock sizes of "Glo-Tech" precision bore pyrex tubing. Also illustrated are many special shapes including square, hexagonal, oval, fluted, and tapered, all of which are regularly being made to customer specification.

A wide range of applications credited to "precision bore tubing" includes high accuracy manometers, barometers, flow restriction nozzles, viscosimeters, bearings, etc.

CHECK THE CARD AT PAGE 240

33—Centrifugal Pumps

A bulletin (No. 52B6691) telling of its new line of "Pedrifugal" pedestal type centrifugal pumps has been released by the Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis. Five sizes of this pump handle all general pumping requirements up to 500 gallons per minute and up to 100-foot head as well as any range of intermediate capacities and heads, it was said.

In addition to diagraming construction features, the bulletin carries pump, motor and Texrope drive selection tables. Standard dimension tables of the "Pedrifugal" pump, which is stocked and sold with or without motors, are also given.

The "Pedrifugal" can be powered by electric motor or gasoline engine.

CHECK THE CARD AT PAGE 240

34—Stainless Steel Fittings

Economies claimed in industrial piping with "Nibcoloy" stainless steel and nickel alloy fittings are emphasized in Catalog 901 issued by Northern Indiana Brass Company, Elkhart, Ind. Besides facilitating the use of light gauge tubes, "Nibcoloy wrot" fittings are said to eliminate most rust and corrosion problems and reduce turbulence because the joints are smooth. Complete labeling of fittings permits the matching of physical and metallurgical properties of tubes and fittings in new installations and in maintenance operations. Dimensions and prices for the complete series of inconel, monel, nickel and stainless steel 304, 347 and 316 fittings from ¼-inch to 4-inch OD are listed.

CHECK THE CARD AT PAGE 240

35—Welding

Victor Equipment Company, 844 Folsom Street, San Francisco, Calif., has issued a 20 page catalog picturing and otherwise describing a comprehensive portion of its line of Victor gas welding and flame cutting apparatus.

CHECK THE CARD AT PAGE 240

36—Gas Controls

"Automatic Controls for the Gas Industry" is the title of a new bulletin by Askania Regulator Company, 240 E. Ontario St., Chicago 11.

Described are various control systems for controlling stack draft, furnace pressure and collector mains in gas producing plants. Booster and exhauster

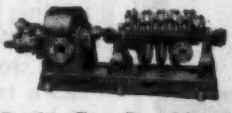
For diversified, continuous duty services in industrial, chemical and process plants, etc. Peerless centrifugal pumps incorporate many proven design features for extended pump life, minimum down-time and operative economy. They are manufactured in an extensive series of advanced types, sizes and capacities up to 70,000 G. P. M.

TYPE A
General Service Pump

Peerless type A pumps afford top-flight, continuous duty operation with capacities from 50 to 70,000 g.p.m. Heads: 15 to 300 ft. All types of drives: 1 to 1000 h.p. Sizes: 2" to 42" discharge. Split-case, single stage, double suction type.

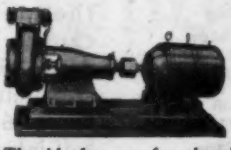
TYPE AF
Fire Pump

Peerless Underwriters' Approved fire pumps are available for all fire protection services. Capacities: 500 to 2000 g.p.m. Pressures: to 150 lbs. single and double stage types, for electric, engine, turbine drive or combinations.



TYPE B
Boiler Feed Pump

Peerless Type B multi-stage pumps are designed for boiler-feed, pipe line and refinery services delivering capacities up to 900 g.p.m. against pressures up to 700 lbs. For electric and other type drives from 60 to 350 h.p.



TYPE DS
Process Services Pump

The ideal pump for chemical, oil, soap and similar process services. Capacities: 10 to 1500 g.p.m. Heads: up to 231 feet. Handles a wide variety of corrosive or non-corrosive liquids at temperatures up to 200° F.; pressures to 100 lbs. Single stage, single suction.

PEERLESS PUMP DIVISION • FOOD MACHINERY CORP.

Factories:
Indianapolis, Ind. • Quincy, Ill. • Los Angeles 31, Calif.
District Offices: **Canton 2, Ohio; Philadelphia: Suburban Square, Ardmore, Pa.; Atlanta: Rutland Bldg., Decatur, Ga.; Dallas 1, Tex.; Los Angeles 31, Calif.**

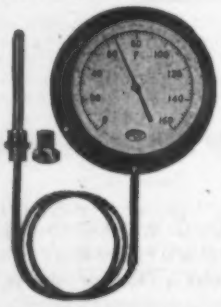
PEERLESS PUMPS
FOR MOST SERVICES
IN ALL INDUSTRIES

IT DOESN'T TAKE A "SECOND LOOK"

with the NEW PALMER Thermometer

Recording Thermometer

12 in. die-cast aluminum case. Electric or spring clock 12, 24 hour or 7 day charts available in all ranges. Fountain pen standard.

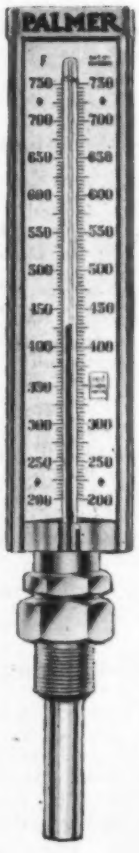


Dial Thermometer

Fully compensated 8" round case. Standard dials available for all ranges. Equipped with micrometer adjusted hand. Atomic welded construction.

You don't have to squint or strain to get positive readings with the new Palmer Thermometer. The new extruded case permits a larger reading scale, and Palmer's "Red-Reading Mercury" feature stands out vividly . . . like a traffic light on a rainy night.

And both Beauty and Accuracy are combined in this new thermometer. Beautiful chrome finish is a standard on 7, 9, and 12 inch case sizes, durable nickel on the 4 and 6 inch case sizes. For full information write for new Bulletins 46-2 and 46-3.



Palmer "Superior" Recording and Dial Thermometers are Mercury Actuated. Extremely accurate and sensitive. Constructed for long service. Flexible armoured tubing and bulb of stainless steel. All ranges up to 1000F. or 550C.

Look for Palmer Booth 77
Instruments Exhibit
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PALMER THERMOMETERS INC.

Mfrs. of Industrial, Laboratory, Recording and Dial Thermometers
2513 NORWOOD AVE., CINCINNATI 12, OHIO
Canadian Plant:
KING AND GEORGE STS., TORONTO 2

controls, either for single or parallel operation, are explained in detail.

Gas mixing systems including protane-butane, both by straight volumetric methods and with BTU correction, also are described.

CHECK THE CARD AT PAGE 240

37—Equipment Level Control

Original engineering thinking, based on the most recently developed needs of the process industries, is embodied in the Kontrol Motor line of pressure regulators and diaphragm motor valves described in Catalog 47 released by Kieley & Mueller, Inc., North Bergen, New Jersey. The equipment illustrated capitalizes fully on production methods evolved since the war, and several units shown are said by the firm to represent great advances.

The catalog's five sections cover, in addition to diaphragm valves, the company's lines of liquid level controllers, strainers, pressure reducing and regulating valves, pump governors, and such steam plant equipment as back pressure valves, atmospheric relief valves, diaphragm relief valves, oil and grease extractors, and exhaust heads.

CHECK THE CARD AT PAGE 240

38—Fire Extinguishers

The cartridge-operated 2½-gallon Pyrene water type and Pyrene antifreeze fire extinguishers are described in a bulletin issued by Pyrene Manufacturing Company, Newark, New Jersey. These cartridge-operated extinguishers are maintained by simple examination and by weighing the gas cartridge.

CHECK THE CARD AT PAGE 240

39—Expansion Joints

Chicago Metal Hose Corporation, Expansion Joint Division, Maywood, Ill., has issued Bulletin EJ-47, descriptive of CMH "Free-Flexing" and "Controlled-Flexing" bellows-type expansion joints for controlling expansion, vibration, and misalignment in pipe lines having pressures to 300 psi and temperatures to 900° F.

"Free-Flexing" and "Controlled-Flexing" designs with copper and stainless steel corrugations are illustrated, and data are given for each type in the bulletin.

CHECK THE CARD AT PAGE 240

40—Low-Temperature Insulation

The Industrial Mineral Wool Institute, 44 Lexington, New York 17, has published a new manual entitled "Holding Low Temperatures with Better Insulation."

The booklet offers instruction in the selection of insulation, data on forms, properties and application methods and a useful chapter on the principles and significance of vapor-proofing for various types of wall, floor and ceiling construction. The work contains photographs, charts and tables, and analyses of typical case-history installations in

cold storage work, freezing processes, cold-aging, food distribution, industrial refrigeration, and air conditioning.

CHECK THE CARD AT PAGE 240

41—Rubber-Clad Electrical Connector

Bulletin 201, describing and illustrating the R-C-E Industrial rubber-clad electrical connector has been issued by Industrial Power & Equipment Company, 406 Millbridge St., Pittsburgh 10, Penna. It points out advantages of the connector's use on portable, mobile or stationary machinery, wherever cable circuits and extensions are required that must frequently or occasionally be disconnected.

CHECK THE CARD AT PAGE 240

42—Water Conditioning

The essential function of a hot process water conditioning system is explained and diagrammed in a new 12-page bulletin (28B6611) released by Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Included is a description of the equipment and an explanation of what it is designed to do, together with the mechanism of its operation.

The bulletin tells of the system's reaction and sedimentation tank, raw water inlet regulating valve, spray heater, vent condenser, vacuum breaker, recording thermometer, and chemical feeding equipment. It also discusses condensate and treated water storage.

CHECK THE CARD AT PAGE 240

43—"Poison" Danger Debunked

A four-page bulletin entitled "Is There Poison in Your Corrosion Resisting Alloy?" released by The Duriron Company, Inc., Dayton, Ohio, deals principally with the presence of copper as a possible solution contaminator in corrosion-resisting alloys. With engineering "reason-why" copy, the folder gives specific data on this question. Where caution is necessary in this matter is pointed out.

CHECK THE CARD AT PAGE 240

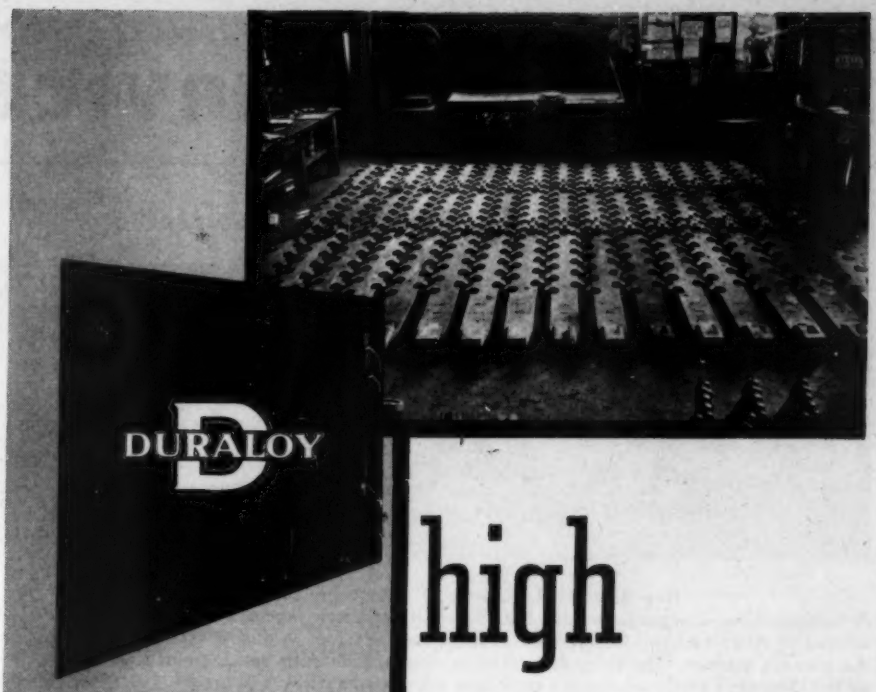
44—Alloy Products

The Duraloy Company, Scottdale, Pennsylvania, has issued Bulletin 4729-G, which gives specifications of its alloy products for processing under corrosive, high temperature and abrasive conditions. In addition to specifications of its several products, graphs are used to further outline the metals.

CHECK THE CARD AT PAGE 240

45—Bolts, Nuts, Washers

Pawtucket Manufacturing Company, 349 Time Street, Pawtucket, R. I., have issued a new catalog, No. 46, which is intended to offer a convenient means for selecting brass, bronze, silican bronze, stainless steel, and monel metal bolts, nuts, washers, and screws. The catalog, which is in simple tabular form, provides specific information and price listings on a wide variety of types and sizes, and can be obtained free upon request.



DURALOY

high alloy tube supports for refineries

The reason we can consistently turn out sound chrome-iron and chrome-nickel castings is that we specialize in this work. All our metallurgical talents, our skilled foundrymen, our equipment and controls are geared to the exacting business of producing high alloy castings.

With a large modern foundry, we are in position to produce not only tube supports but any other casting, up to about 6 tons per casting (static) and up to about 15 feet in length and 24 ins. O.D. (centrifugal).

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Chicago & Detroit F. B. CORNELL & ASSOCIATES

About EQUIPMENT—SERVICE Suppliers

New Research Laboratory Occupied

New Research Laboratory of Attapulgus Clay Company

Attapulgus Clay Company recently has moved its research laboratory into a modern building located at Airport Circle, Camden, N. J. Space now occupied is almost three times greater than the previous quarters. The entire laboratory is equipped for both basic research and control work on the company's products—fuller's earth and activated bauxites. The greater space has permitted both an increase in staff as well as an extension of all laboratory activities. The building also contains extensive office space and a large storage area for apparatus, chemicals and sample materials. A reference library also is included.

Benzene Hexachloride Plant Is Opened By Pennsalt

A new manufacturing unit greatly expanding its production of the new insecticide, benzene hexachloride, has been completed and put in operation by Pennsylvania Salt Manufacturing Company at its Natrona, Pa., plant.

The technical product is being used to formulate, at Natrona, Pennsalt's previously announced benzene hexachloride products, including D-10, a dust base containing 10 percent gamma isomer made for manufacturers of insecticide dusts; D-5, a similar product containing five percent gamma isomer; W-10, a wettable base product for use as a suspension spray containing 10 percent gamma isomer; Emulsion Concentrate, a water miscible solution containing 9 percent gamma isomer, and Solvent Concentrate, a compound with 9 percent gamma isomer for the manufacture of oil base sprays.

The new plant, said Pennsalt officials, was specially designed and embodies the latest developments worked out by several years of research and process development at Pennsalt's Whitemarsh Research Laboratories.

E. A. Wert Named Head of New Chicago Metal Hose Division

The Chicago Metal Hose Corporation has appointed Edwin A. Wert as director of sales for its new expansion joint division with offices in Maywood, Ill.

Wert

Wert was formerly with The Detroit Edison Company where he had been engaged in an engineering and design capacity for 18 years, and at present as honorary consulting engineer. He is the author of various publications in the power piping field.

For 4 years Wert was vice president in charge of engineering and sales of Blaw-Knox Company, power piping division,

LENAPE SPECIAL MANWAYS

SIMPLIFY DESIGN AND KEEP COSTS LOW

When access openings of special type or special material are indicated, you may minimize both design time and construction cost by referring your requirements to Lenape.

We are regularly producing special constructions for chemical, refinery, food, cosmetic, beverage, pharmaceutical, and similar applications, in addition to our standard line.

Our recommendations as to type and material will simplify your design, procurement, and cost problems in the planning and initial estimate stages.

Type SR 18" Manway and swing cover of #347 Stainless with mild steel trim.

Quotations will be given our immediate attention—Bulletin 4-61 and current price schedule M-47 will be sent upon request.

LENAPE HYDRAULIC PRESSING AND FORGING CO.

LENAPE HYDRAULIC PRESSING & FORGING CO.
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EVERLASTING FASTENINGS

and for several years he was consulting engineering for Pittsburgh Piping & Equipment Company.

He is an alumnus of the University of California and a member and contributing author of ASME.

Morpholine Again Available

Morpholine, a volatile compound that inhibits corrosion due to carbon dioxide in steam and condensate-return lines of steam heating or processing systems, is once again available after several years' shortage during the war, Carbide and Carbon Chemicals Corporation, 30 East 42nd Street, New York 17, has announced. It is suggested by the company for the treatment of feedwater for boilers supplying low- or medium-pressure steam to heating or processing systems with extensive piping or condensing surfaces.

WANTED—MECHANICAL OR METALLURGICAL ENGINEER—familiar with the inspection of refinery fractionating equipment, furnaces, heat exchangers and pressure vessels and having experience to qualify for making recommendations for renewal or repairs to the equipment. Experience on catalytic cracking units preferred, but not essential. In replying, please send full details of experience and education. Snapshot (if available). Address: Box 10-R, c/o Petroleum Refiner, Houston, Texas.

PETROLEUM ENGINEER wanted with a background in coal tar and asphalt. Must be well versed in design of bitumen, handling and blending equipment and in the chemistry of asphalt and coal tar, and the blending and admixturing of same. Please state age, experience, educational qualifications and salary expected in reply. Address: Box 98-R, c/o Petroleum Refiner, Houston, Texas.

ENGINEERS—Stanolind Oil and Gas Company, P. O. Box 591, Tulsa, Oklahoma, has opening for graduate chemical or mechanical engineer with two or more years experience in gasoline or recycling operations. Address: Box 206-R, c/o Petroleum Refiner, Houston, Texas.

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HEATERS
FOR EVERY PROCESS THERE IS A
BORN UPFLO HEATER
BORN ENGINEERING CO.
TULSA, OKLAHOMA

New District Managers

Honefenger

Maag

Elliott Company, Jeannette, Pa., has announced that J. M. Maag is now Kansas City district manager and that T. W. Honefenger, who joined Elliott Company in 1936 as field engineer of the St. Louis office, has been appointed St. Louis district manager succeeding Maag.

Maag was a field engineer in the Elliott Chicago office, 1925 until 1941, when he became St. Louis manager.

National Supply Promotes Cushing to Wyoming Post

W. T. Cushing, Jr., who has been in the plant products division of The National Supply Company at Houston, has been promoted to division engineer of the company's northwest division at Casper, Wyo. The northwest division also includes the company's activities in Western Canada.

J. W. Chadwich, whom Cushing succeeds, will continue in an advisory capacity and will retire at the end of the year after 18 years service with the company.

Armstrong Cork to Build New Laboratory Facilities

Bids for construction of the research facilities on a 40-acre site, three miles from Lancaster, location of the home offices of Armstrong Cork Company, will be asked late this fall. It is hoped that the planned new laboratory will be ready for use by the summer of 1949.

The new facilities will include latest developments in industrial research and laboratory design and equipment. In addition to the main building, a large pilot plant, several smaller pilot plants, and a boiler house will be built.

Calco Appoints Cooper

Calco Chemical Division, American Cyanamid Company, Bound Brook, N. J., has announced the appointment of Dr. H. B. H. Cooper as an assistant manager of the development department. Prior to his present appointment, Dr. Cooper held the position of divisional engineer of the rubber chemicals, pharmaceuticals and coal tar products refining divisions.

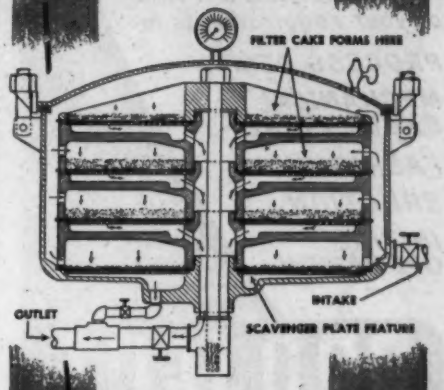
Chicago Representative

Robert M. Simpson has been named acting district manager for the Chicago territory of Pittsburgh Plate Glass Company. A graduate of Cornell University, Simpson has been associated with the Pittsburgh firm's Columbia Chemical Division since 1944.

Fairbanks, Morse Promotion

Fairbanks, Morse & Company has announced appointment of L. A. Weom as

the horizontal plate principle



. . . makes these the "filters that filter all liquids."—

SPARKLER
Horizontal Plate
FILTERS

. . . and here's the story:

- Sparkler Horizontal Plate Filters handle any liquid from heavy varnishes to light alcohols, including products such as acids, oils, beverages, milk, pharmaceuticals, plating solutions, water, etc.
- Equally efficient performance on intermittent or continuous operation, under a wide range of temperature, pressure and viscosity conditions.
- Equally effective whether removing carbons and contact clays or clarifying and polishing with filter aids.
- Patented Scavenger Plate permits complete batch filtration. (It's virtually an auxiliary filter with an independent control valve.)
- Unexcelled filter cake stability—no slipping or breaking.

. . . why?

Because filter media are supported on a horizontal plane and filter aids floated into position uniformly, filtration takes place uniformly over entire filtering areas. Flow through filter is always *with* gravity.

Sparkler Filtration Is *Engineered* Filtration—we invite correspondence on your problem. You will receive the advice of filtration scientists with a quarter of a century of experience in a specific field.

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is preferred by leading refineries because of its high copper content, dependable uniformity and exceptional purity and freedom from foreign and inert matter.

99%+ PURE

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230 N. MICH. AVE., CHICAGO

manager of the company's Pump Division to take the place of Arnold Brown, resigned.

Weom started with the company in 1929 in the Pump and Electric Department at St. Paul, Minn. In 1932 he became a field engineer, in 1936 he was promoted to manager of the Pump and Electric Department of the St. Paul Branch which position he held at the time of his recent appointment. He was an officer in the United States Navy during World War II.

Santomerse Facilities Are Increased by Monsanto Plant

Completion of a new $3 million plant at Monsanto, Ill., for the manufacture of "Santomerse No. 1," a synthetic detergent, has been announced today by Monsanto Chemical Company.

The one-story concrete building gives Monsanto additional large-scale facilities for manufacturing this product. Production also will continue at Monsanto's Nitro, W. Va., plant.

Among advantages possessed by "Santomerse" is the ability to function efficiently and economically in water which is hard or soft, hot or cold. It also functions in either acid or alkaline solutions and prevents formation of insoluble curds, scum, or rings in hard water.

Bethlehem Supply Changes

J. R. B. Freeman, formerly refinery sales representative in Los Angeles for Bethlehem Supply Company of California, has been appointed district manager of the San Francisco area. W. H. Weitzel will continue as manager of the San Francisco store.

In Los Angeles, R. B. Trimble will take over J. R. B. Freeman's activities under the direction of H. E. Chapman in refinery sales; R. A. Casson, in addition to his duties in the sale of pumping units, will take over R. B. Trimble's work in the sale of sucker rods and wire rope.

Gulf Engineers Add New Division for Refining

Gulf Engineers, Inc., 2949 Jensen Drive, Houston, has added a new division specializing in refinery and chemical plant equipment. Hayes O. Trego, an experienced oil field equipment sales engineer heads up the new sales department, according to Frank Cavenagh, vice president and general manager of the company, himself a valve specialist for 25 years prior to his affiliation with this company.

Cavenagh

Gulf Engineers have been named exclusive representative for the sale of The Calorizing Company's products in Louisiana, Oklahoma, and Texas. Calorizing products embrace a line of heat-enduring metals used in oil refinery and other chemical process industries. The Company is the licensee for the Calorizing process whereby aluminum is driven into the surface of carbon or low alloy steels to form an iron-aluminum alloy, said to be immune to oxidation up to 1500°F. It also manufactures Calite alloys, a line of chrome-nickel materials in cast, rolled or forced form.

Gulf Engineers, incorporated in 1934, also handle indicating and recording specialties made by Uehling Instrument Company, tachometers, adapters, etc., made by Metron Instrument Company, flexible metal hose made by Atlantic Metal Hose Company, and other items.

Foster Opens in Houston

L. B. Foster Company has opened offices and warehouses in Houston, with Jerome B. Strauss as manager and offices in the Electric Building. Foster's new distribution facilities in Houston

Factory and Office Building Opened

American Meter Company has opened its new factory and office building, 950 Tennessee Street, San Francisco 7, where will be coordinated its total gas meter production for the Pacific Coast. The factory is equipped with the most modern machinery and facilities for the manufacture, repair and testing of gas meters.

will be similar to those maintained in San Francisco, Chicago, Pittsburgh, and New York.

The Foster company distributes steel rails and track accessories as well as steel piling, pipe, etc.

Uniform Name Chosen for Portable Fire Extinguishers

A change in name for the complete line of General portable fire extinguishers has been announced by The General Detroit Corporation.

The name, "Quick Aid Fire Guard," hereafter will be applied uniformly to all types of portable fire extinguishers manufactured by The General Detroit Corporation and its subsidiaries, The General Pacific Corporation and The General Detroit Corporation, Canada, Ltd.

Until now, General's eight types of portable fire extinguishers have borne the brand names of S. O. S. Fire Guard, CD-Sno Fog, Red Star, Hi-Test, Floafome, Alaskan, Protector, and Pacemaker.

Hopkins Named Executive at R-S Products Corporation

R-S Products Corporation, Philadelphia, has announced the promotion of David W. Hopkins to executive vice president, giving him full administrative authority in the valve, furnace and manufacturing divisions. Hopkins has been with R-S Products Corporation since 1939, and just previously was in charge of its valve division.

Hopkins

Noteworthy in his background is extensive research at the University of Pennsylvania, with Professor W. S. Pardoe. Results of this work include many basic advances in valve construction and performance.

LN Executive Retires

Oscar Brewer, sales engineer of Leeds & Northrup Company and for several years Philadelphia industrial division sales manager, has retired after nearly 39 years with that organization.

At the time of his retirement nearly 100 of his friends from the Leeds & Northrup organization honored him at a testimonial dinner and gave him a gold watch.

H. R. Abey is his successor as Philadelphia industrial division sales manager.

Bonnet Is Assistant

Charles F. Bonnet has been appointed assistant to Arthur J. Campbell, general sales manager, Industrial Chemical Division, American Cyanamid Company. Bonnet will continue as manager of the Petroleum Chemicals Department, and H. E. Nehms will be acting department head.

Named Technical Manager

Vincent J. Calise has joined Liquid Conditioning Corporation of Linden,

THERE is a wealth of practical, up-to-date factual information about expansion joints and flexible connectors packed into this *new* 60-page catalog compiled by the technical staff of Zallea Brothers & Johnson.

For instance, twenty double-pages offer specific, usable data on the many types of Zallea expansion joints. There's a full description of the manufacturing process for every expansion joint that includes welding and forming, annealing, pickling and passivating.

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EQUIPMENT INSPECTOR: 5 years refinery experience with substantial equipment inspection experience involving familiarity with all refinery equipment and established codes of construction.

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New Jersey, in the capacity of technical manager.

Calise has long been associated with the development and production of ion exchange materials and the practical application of such materials in zeolite water softeners and other types of cation and anion exchange equipment. His experience has also included the design, construction and operation of all types of water treating equipment.

Clarke Named Representative Of Hammel-Dahl Company

O. T. Clarke, Clarke Sales Engineering Company, Decature, Ga., has been named dealer representative in the Southeast for Hammel-Dahl Company. A graduate of Princeton, Clarke was a member of a student engineering class of Standard Oil Company after completion of which he joined the sales department. In 1932 he became affiliated with The Pure Oil Company and in 1944 joined Shell Oil Company which he left in February, 1947, to organize his own company. His work has been principally with industrial, marine, and utility companies.

O. T. Clarke

Tesco Now Manufacturing Stainless Steel Castings

With the recent addition of a special new, flexible type furnace at Texas Electric Steel Casting Company, Houston, high alloy steel castings for heat and corrosion resistant applications have been made available on a commercial scale.

Tesco thus brings an additional source of supply for stainless steel castings into the area, which will put control of casting problems nearer foundry facilities and services.

The new Tesco furnace is highly flexible and will handle castings from a few pounds up to more than a ton. These stainless steel castings are made to customer specifications.

Addition of this new type furnace by Tesco for corrosion resisting castings brings their facilities to full strength.

Humphreys Named Safety Head Of American Car and Foundry

American Car and Foundry Company announces the appointment of Forest H. Humphreys as manager of its safety and claims division, to succeed Karl N. Searles, recently retired. Humphreys will have charge of safety and claims in all ACF plants, but will continue headquarters in New York.

His entire career has been devoted to safety since he graduated from the Jeffersonville, Ind., high school and went into the ACF Jeffersonville plant as a riveter. He continued his education at night. In August 1927 he became manager of safety and claims and employment at the Jeffersonville plant, and in August 1932 the company brought him to New York as assistant general supervisor, safety and claims division.

Humphreys has contributed a number of articles to national safety magazines. He conducted one of the first all inclu-

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sive eye protection programs in industry, pioneered in organizing elementary school safety clubs, appearing on programs of Greater New York Safety Convention and National Safety Congress.

He is a member of the American Society of Safety Engineers, active in the affairs of the Metropolitan Chapter, A.S.S.E., a member of the executive committee of the Automotive and Machine Shop Section National Safety Council, member of Safety Executives Club, etc.

Other personnel changes include appointment of Frederick H. Eaton as assistant vice president of ACF's export company and Lloyd H. Mulbarger as sales engineer in the New York office. Eaton will concentrate his efforts in the foreign field.

New District Managers For Du Pont TEL Sales

Five district offices have been designated and managers named as plans progress for the Du Pont Company to market tetraethyl lead antiknock compound for motor and aviation fuels beginning Jan. 1, 1948. A complete petroleum chemicals service laboratory will be set up in each district.

Du Pont's present contract with Ethyl Corporation expires at the end of 1947 after which date these anti-knock compounds will be sold direct to the refining industry through Du Pont's Petroleum Chemicals Division.

District offices and managers include: Tulsa, for the Mid-Continent District, Charles Wirth, III; Houston, for the Gulf Coast District, Joseph A. Hyland; Los Angeles, for the West Coast District, David H. Conklin; Chicago, for the Chicago District, Earl G. Bennett, and Wilmington, Del., for the Eastern Division, Norman Kent.

Named Advertising Manager

J. K. Rector, formerly assistant advertising manager of E. W. Bliss Company, has been appointed advertising and sales promotion manager of Watson-Stillman Company, Roselle, N. J., manufacturers of hydraulic machinery and mill distributors' products.

Prior to his entry into the field of advertising, Rector held both technical and general administrative positions in the fields of petroleum, refining, and machine tool production.

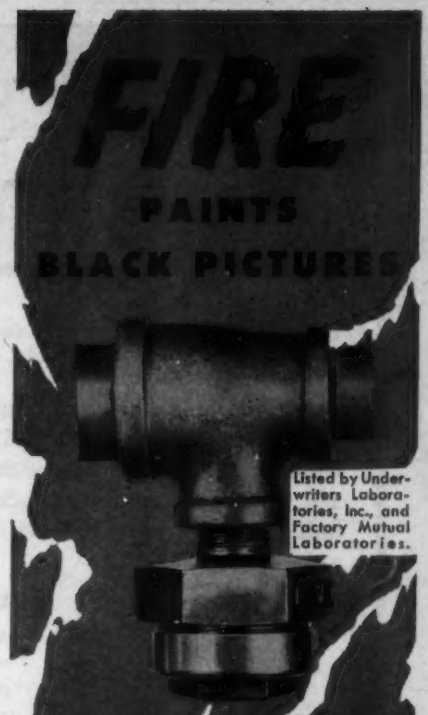
Kuehmsted to New York

A. M. Kuehmsted, chief engineer for Santa Fe Tank and Tower Company in Los Angeles for the past 12 years, has been assigned to the New York branch. He will take over the district management of cooling towers, air cooled units, and wood tanks at Santa Fe's New York office, 400 Madison Avenue.

Brown Names Sales Engineers

Appointees to branch and regional offices of Brown Instrument Company, all graduate engineers who have completed postgraduate courses at the Brown School of Instrumentation at Philadelphia, include the following:

Edgar Andrews, Atlanta; Nilsson S. Bassett, Boston; R. J. Bierman and Clarence W. Swanson, Minneapolis; Edward J. Bryne, Houston; Warren H. Erftenbeck, Buffalo; David J. Fair,



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3 Deliver powerful fog—strike to base of fire in spite of drafts and air turbulence, indoors or outdoors.

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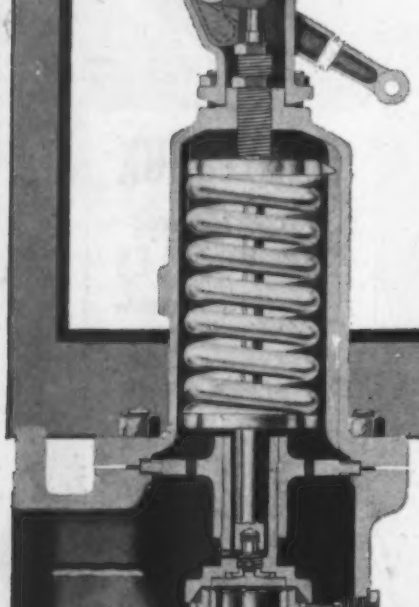
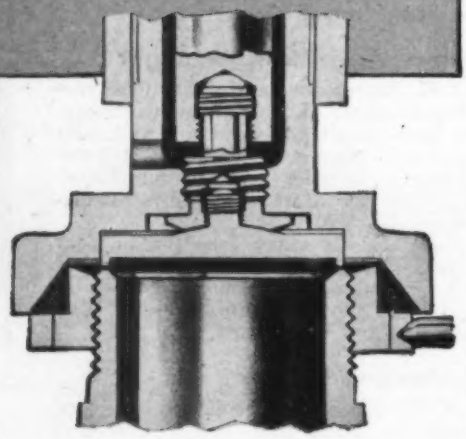
Other cost saving advantages:

- **The small center disc piece which takes all the beating can be easily replaced for a few dollars when necessary without replacing the whole assembly.**
- **The inverted cone or secondary nozzle retains its full certified capacity without need of adjustments which always causes loss of capacity. This fact coupled with a coefficient of flow efficiency established at 97½ means that a smaller valve can be used.**
- **Minimum stock parts need be carried because such parts are completely interchangeable.**





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Dallas; William R. Hamaker, Detroit; Charles F. Hintz, Chicago; Lawrence W. King, New York; Donald W. Larcen, Milwaukee; John F. Smith, Tulsa, Okla., and Andrew H. Albee, Cleveland, Ohio.

Leyman Representative Named

Leyman Manufacturing Company, Cincinnati, announces the appointment of Dean F. Gunby as the Houston district sales manager for McGowan Pumps and Kodweld Products. Stocks of pumps and spare parts will be warehoused in Houston. Gunby also will have complete charge of facilities for servicing petroleum and industrial requirements in the Southwest.

Gunby

Offices of Leyman Manufacturing Company are in the Jameson Building, 1903 Blodgett Street, Houston.

New Byron Jackson Plant

Completed recently and now occupied, a new plant addition of the Byron Jackson pump division covering approximately 8 acres on the south side of Vernon Avenue, Vernon, Calif., supplants buildings on Slauson Avenue in Huntington Park, occupied since 1920. The new addition includes an administration building, and provides for machine shops, stock room and warehouse, shop cafeteria, service and pattern shops, truck shed, garage and maintenance, and oil and paint storage.

All phases of the building operations, a $1.5 million project, were under the direction of Floyd C. Merritt, vice president of the Oil Tool Division.

Walker Named by Hooker

James S. Walker, a graduate chemist of Union College, who joined the Hooker staff in 1940, has been appointed technical service representative of Hooker Electrochemical Company. He was engaged in process supervision prior to his recent appointment.

With Niagara Falls as his headquarters, Walker will handle problems related to the shipping, storing and handling of all Hooker chemicals. He will emphasize the elements of safety in the handling of Hooker products in the consumers' plants, it was announced.

Porter Pacific Manager

H. K. Porter Company, Inc., has announced the promotion of Harold A. Hintz to Pacific Coast sales manager. He will direct the activities of all Porter sales offices on the Pacific Coast and will maintain headquarters in the Petroleum Building, Los Angeles.

J. F. Morley has been named district sales engineer, with offices in Monadnock Building, San Francisco.

Cadet Engineers Assigned

Two members of Bailey Meter Company's 1946-47 cadet engineering class, J. H. Wilson, Purdue graduate and R. W. May, Clarkson graduate, have been assigned to the company's branch

offices in Cincinnati and New York respectively.

Another training course started in July with 15 graduate engineers and one engineering student attending. A six-month course in instrumentation and automatic control is given.

Thor Thornson Is Appointed Sales Manager of Airetool

Thor Thornson has been named general sales manager of the Airetool Manufacturing Company and will be in charge of sales, advertising and promotion.

Thornson

As a refinery engineer, Thornson has spent 15 years in oil refineries on all types of operations in Michigan and Canada. His experience, which includes refinery maintenance, construction and operation, covers from the days of the old shell still method of refining to the modern cracking methods which now prevail.

Vockrodt to Represent Alloy Steel Products

E. M. Vockrodt, 3757 Wilshire Boulevard, Los Angeles, 5 has been named Pacific Coast representative of Alloy Steel Products Company, Linden, New Jersey. Previous to his duties in the Army Air Forces as Lieutenant Colonel, he was manager of sales for Ducomon Metals and Supply Company and previously he represented Crane Company.

Lowdermilk Becomes Pennsalt Supervisor of Development

Dr. Ford R. Lowdermilk has been appointed supervisor of the development division in the Research and Development Department of Pennsylvania Salt Manufacturing Company. He replaces Frank R. Murphy, recently appointed assistant production manager in Pennsalt's manufacturing department.

Before joining Pennsalt, Dr. Lowdermilk was associated with the Barrett Division of the Allied Chemical and Dye Corporation in the research and development department and as technical assistant to the chief chemical engineer.

Haddox to Pittsburgh

Ralph Haddox, assistant manager of the tubular department of Oil Well Supply Company, has transferred his headquarters from Charleston, W. Va., to Oil Well Supply Company, 1607 Frick Building, Pittsburgh, Pa.

Haddox, former president and general manager of United Pipe and Supply Corporation of Charleston, was appointed to his present position with Oilwell in March.

Globe Transfers Scott

John F. Scott has been named chemical and metallurgical sales representative of Globe Steel Tubes Company's New York district office.

Scott joined Globe in 1940 as metallurgist in the laboratories and early in 1947 was transferred to the Milwaukee general sales office.

Darnell Joins Bjorksten

Dr. Johan Bjorksten, president of the Bjorksten Research Laboratories of Chicago, has announced that James R. Darnell has joined the company in the capacity of assistant to the president.

Darnell was educated at Carleton College, Northwestern University, and the University of Illinois from which he was graduated in June, 1942. Subsequently, Darnell was employed as a chemist by Corn Products Refining Company and The Pure Oil Company. He also taught chemistry at Trinity University in San Antonio.

Chicago Offices Moved

C. J. Tagliabue Manufacturing Company, Brooklyn, a subsidiary of Portable Products Corporation, has moved its Chicago district sales offices from 608 South Dearborn Street to Room 1120 Merchandise Mart, Chicago 54. The new offices, incorporate a large display room.

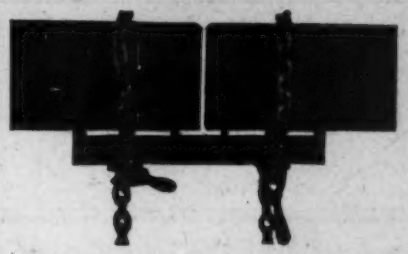
Sales Manager Named

Joseph J. Duffy, Jr., has been named manager of sales of the Special Chemicals Division of the Pennsylvania Salt Manufacturing Company.

Duffy, assistant manager of sales in the division since February, 1945, assumes the position formerly held by William P. Drake, recently appointed assistant vice president.

Chain Belt Appointment

Charles Stanton has been appointed district field-engineer in the Philadelphia office of Chain Belt Company, Milwaukee, Wis. He formerly held a similar position in the company's Detroit office.



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They align pipe perfectly and hold it secure for tacking. On in a minute—off in ten seconds. Two sizes, ½ to 8 in. — 8 to 16 in. Rigid construction resists strain, heat, and abuse.

Other Jewel Clamps for Ells, long and short turn — for Flanges — for Headers. Also Pipe Marker, eliminates patterns for holes and saddles.

So simple — so easy to use — Jewel Tools are proving big time-savers in refinery piping fabrication and erection.

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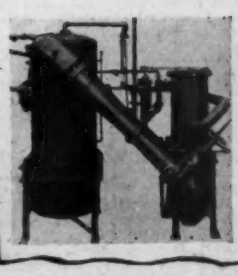
NOW is the TIME to consider next summer's



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Too bad, but it's too late to order a CHILL-VACTOR for use this summer. If this equipment could be stocked on shelves we'd be glad to ship your order tomorrow. Trouble is, it takes three or four months to design, build and ship a complete CHILL-VACTOR Unit.

That is why you ought to start thinking NOW about ordering your CHILL-VACTOR for next Summer's cooling requirements. You should begin now to assemble your data, check your capacity requirements, and be ready to specify equipment which will provide maximum benefit.

CHILL-VACTOR equipment answers the need of chemical and process industries for:

Maintaining proper temperatures in certain solutions.

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Special cooling requirements.

The Croll-Reynolds CHILL-VACTOR is one of the most dependable and efficient units available for many cooling requirements in the range above 32° F. It has no moving parts other than a standard chilled water circulating pump. Water is the only refrigerant.

Maintenance and repair costs are practically nil. Operating costs are usually less than for other types of refrigerating equipment where ample condenser water is available.

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